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Research article

Moderate and Severe Injuries at Five International Olympic-Style Wrestling Tournaments during 2016-2019

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Abstract
As a contact sport, wrestling may result in injuries. Based on the severity, they are classified as mild, moderate, severe and critical. All injuries occurring at international competitions are documented in a cloud-based surveillance system. The purpose of this study was to analyze the incidence and characteristics of moderate and severe (including critical) wrestling injuries that occurred during five international Olympic-style wrestling competitions in 2016-2019. Three Wrestling World Championships and two European Wrestling tournaments were organized by the Hungarian Wrestling Federation in 2016-2019. A total of 2483 wrestlers in three Olympic wrestling styles have competed in 3007 matches. Data from all injuries were recorded and analyzed to define rates, locations, types and severity, and to compare with previous reports. A total of 53 wrestlers sustained 55 injuries, which is equivalent to an overall injury incidence rate of 9.1‰ (9.1/1000 athletic exposures). Greco-Roman and Women Wrestling had the same injury incidence rate, while Freestyle had a lower one (9.5‰ versus 8.5‰). The injury proportion by regions and anatomic locations were on head and face 29.1%, spine and trunk 16.4 % and the upper-and-lower extremity injuries equally 27.3%. The most common types of injuries included ligament lesions, joint injuries, skin lacerations, and contusions. Five wrestlers (0.8‰) sustained strangulation or concussion. Wrestling injury rates during United World Wrestling competitions are not high, but when happen they can be serious. Despite relatively low incidence rate of injuries, there is a need for continuous education for medical teams, referees and coaches to avoid wrestling injuries.

Key words: Wrestling; injuries; head-and-trunk; extremities; strangulation; incidence

Introduction

Olympic wrestling is a high-demand contact sport, which occasionally results in injury (Halloran, 2008; Shadgan et al., 2010). Prevention and reduction of injuries are considered as main priorities by the United World Wrestling (UWW), the international governing body of Olympic styles wrestling. One of the main structures of this international sports federation is the Medical, Prevention and Anti-Doping Commission (UWW-MC). Continuous upgrading and monitoring of the UWW Medical Regulations and direct supervision of the medical and doping control coverages of wrestling competitions are essential duties of the UWW-MC (UnitedWorldWrestling, 2019a). A Practical Medical Guide for Wrestling Competitions is also prepared to help those physicians or health care providers who are neither familiar with the wrestling rules nor with common wrestling injuries (Molnár et al., 2014). To understand and control wrestling injuries, all injuries and medical conditions during UWW competitions are recorded and analyzed by UWW-MC through a well-established secured cloud-based surveillance system, so-called "Athena". This information helps to monitor and consider proper actions to prevent injuries and improve the safety and the healthcare of wrestlers (Channon et al., 2020).

Understanding the mechanisms of wrestling injuries is essential to prevent and reduce the risk of injuries; however, it is not always easy in wrestling due to the complexity of movements in this sport (Molnár et al., 2020; Myers et al., 2010). Besides frequent contacts and collisions during wrestling, inadequate preparation or loss of concentration can result in injuries too (Maffulli et al., 2010; Molnár et al., 2020). The dietary regimen may also contribute to physical injuries in wrestlers (Barley et al., 2019; Jlid et al., 2013; Khodaee et al., 2015; Kim and Park, 2021; Lingor and Olson, 2010). Though the bouts and training sessions take part in soft mats, tested and permitted by UWW and there is an increasing number of other precautions and improvements to defend wrestlers as well, the development of injuries are inevitable (Shadgan et al., 2010; Shadgan et al., 2021; Shadgan et al., 2017; Tomin and Kmetty, 2021).

The definition of injury in UWW competitions includes "any musculoskeletal or soft tissue complaint newly incurred during the competitions that required medical attention regardless of the consequences with respect to absence from sport" (Shadgan et al., 2010; Shadgan et al., 2017). The severity of wrestling injuries is

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categorized by the UWW-MC as mild (treated on the mat), moderate (additional medical care is required after the competition at the venue), severe and critical (competition is terminated by the referee or the venue medical personnel and the injured wrestler should receive emergency care at an equipped medical centre and be immediately transferred to a nearby hospital). Any severe injury that places life in jeopardy is classified as Critical injury (UnitedWorldWrestling, 2019b).

The purpose of this study was to investigate the incidence and the characteristics of contact (direct and indirect) moderate, severe and critical injuries during wrestling competitions by direct observation in order to improve the Medical Service by the local Organizers and by the UWW.

Methods

Moderate, severe and critical injuries occurred during five UWW Wrestling Championships organized by the Hungarian Wrestling Federation from 2016 to 2019 were studied. These competitions included the 2016 and the 2018 Senior World Championships, the 2019 U23 (wrestlers between 18-23 years old) World Championships, the 2017 U23 European Championships and the 2018 U15 (wrestlers between 13-15 years old) European Championships. All competitions included three Olympic wrestling styles, Greco-Roman (GR), Freestyle (FS) and Women Wrestling (WW).

Theoretically one wrestler could compete in many different Championships thus from a statistical point of view we considered every entry individually in each competition.

A medical team consisted of seven health care professionals from the listed authors was in charge of medical coverage and injury data collection by direct observation during all five events. The documentation and the orientational diagnosis were recorded on-site, based on the injury pattern followed by physical examination.

All direct and indirect contact injuries were documented in UWW Injury Report Forms and uploaded into the secured cloud-based UWW injury surveillance system, Athena (UnitedWorldWrestling, 2019b). As there are many ways to quantify athletic exposure, we chose wrestling specific adaptation of International Olympic Committee consensus statement about exposure measures (Bahr et al., 2020).

The collected data were used to calculate the rates of injuries and proportions in different styles and age groups, and to quantify the location, type and severity of injuries. The type of treatment and the continuation of competitions post injury were also studied. The data collected during these competitions was shared strictly for scientific research with the authors of this study and always kept confidential.

Statistical analysis

Chi-squared or Fisher's exact test were used to assess categorical variables. The influencing factors of the severity of the injuries (moderate vs. severe and critical) were determined by binomial logistic regression. The odds ratio (OR) was counted with corresponding 95% upper and lower confidence intervals (CI). Statistical significance was established at the 5.0% significance level. Statistical analysis was performed by SPSS 25 (SPSS package for Windows, Release 25; SPSS Inc., Chicago, Illinois, USA).

Ethical approval

This study was planned, conducted and realized on behalf of the Medical, Prevention and Anti-Doping Commission of the United World Wrestling.

Results

General injury occurance

A total of 2483 wrestlers participated in 3007 wrestling matches, which accounts for 6014 athlete-exposures (AEs) as one match equals two athletes' exposures. A total of 55 moderate, severe and critical injuries in 53 wrestlers were documented, indicating an injury incidence rate of 9.1 injuries per 1000 AEs (Table 1).

Injuries according to wrestling styles and age groups

Although the proportion of injuries in different styles was different (from 27.3% to 38.2%), the injury incidence rate were very close, ranging from 8.5 to 9.5 injuries per 1000 AEs). However the proportion of injuries by age groups (from 12.7% to 58.2%) and the distribution of injury

Table 1. Occurrence of moderate and severe (including critical) injuries during World and Continental Championships organized by the Hungarian Wrestling Federation between 2016-2019.

Competition	Number of athletes			matches			Injuries *(injured wrestler)*		
Styles	GR*	FS†	WW‡	GR	FS	WW	GR	FS	WW
Senior World Championship (non-Olympic weight categories)	56	50	36	65	59	44	3	0	0
U23 European Championship	147	116	91	172	137	107	3	3 (2)	4
U15 European Championships	237	205	174	277	241	201	1	2	4
Senior World Championships	296	266	225	343	306	261	6	4	3
U23 Senior World Championships	217	219	148	255	363	176	8	10 (9)	4
	953	856	674	1112	1106	789	21	19 (17)	15
Sum	2483			3007			55 (53)		
Injury incidence rate / AEs§	6014 AEs						9.1‰ = 9.1/1000 AEs		

*Greco-Roman Wrestling, †Freestyle Wrestling, ‡Women Wrestling, §athletes' exposures

incidence rate (from 5‰ among U15, 13‰ in U23 and 7.5‰ in Seniors) demonstrated a more significant ranging (Table 2).

Injured body parts by regions and by anatomic location

The most common regions of injuries were the head and face (29.1% among the injured body parts with 2.6‰ injury incidence rate), followed by upper and lower extremities (27.3% and 27.3%, respectively – 2.5‰ per AEs). Spine and trunk were injured in 16.4% of the cases which equals to 1.5‰ injury incidence rate. Regarding the anatomic regions, the injuries of the extremities were the most common (54.5%), followed by the head, face, spine and trunk injuries (45.5%).

The most injured body part by anatomic location was the knee (21.8% of injury proportion and 2‰ per AEs), followed by the head (14.5% vs 1.3‰), the face (14.5% vs 1.3‰) and then the ribs (12.7% vs 1.2‰). Other injuries occurred in the shoulder, elbow, hand, fingers, ankle and lumbar spine. All injuries based on their regions and anatomical locations are listed in Table 3.

Type of injury

There were equal numbers of ligament lesions (n= 6 sprain & n= 6 rupture) and joint injuries (n= 3 dislocation, n= 3 subluxation & n= 6 sprain). Other injuries included skin laceration (n= 11), contusion (n= 7 ribs, n= 1 clavicle, n=1 forearm & n= 1 metacarpal), strangulation (n= 3) and concussion (n=2). Muscle injuries, bone fracture and nerve injury were less common. Table 4 depicts the details of injury types including the injury incidence rate per AEs.

Injury severity

56.4% of all injuries were classified as severe (including one critical injury where a temporary paraplegia occurred), and 43.6% were moderate. Table 5 displays combined information of severity and location of injuries in different styles and age groups.

The influencing factors of injury severity (moderate vs. severe & critical) were analyzed by binomial logistic regression. Different variables including age group, wrestling style, weight category and injury location were included in the model. The analysis showed that there was a greater odd of severe injuries on the extremities (4.61 [1.26; 16.92]) (Table 6).

Discussion

Injury is a barrier to sports participation and development (Shadgan et al., 2017). Although wrestling injuries are comprehensively studied by investigators, the definition of injuries and the population of the studies are extremely heterogeneous (Hewett et al., 2005).

It is very difficult to compare injuries if the data search focused on different patterns, such as incidents that officially halted a match (Kersey and Rowan, 1983), or

Table 2. Injuries according to styles and age groups.

Style	Number of matches	Number of injuries	Proportion of injuries	Injury incidence rate / AEs§ (6014)
GR*	1112	21	38.2%	9.5‰
FS†	1106	19	34,.4%	8.5‰
WW‡	789	15	27.3%	9.5‰
Age group	**Number of matches**	**Number of injuries**	**Proportion of injuries**	**Injury incidence rate / AEs§ (6014)**
Senior	1078	16	29.1%	7.5‰
U23	1210	32	58.2%	13‰
U15	719	7	12.7%	5‰

§athletes' exposures.

Table 3. Injured body parts - Number of injuries by regions and by anatomic locations.

Regions Anatomic locations	Number of injuries	Injury proportion by body parts	Injury incidence rate / AEs§ (6014)
Head & Face	**16**	**29.1%**	**2.6‰**
Head'	8	14.5%	1.3‰
Face''	8	14.5%	1.3‰
Spine & Trunk	**9**	**16.4 %**	**1.5‰**
Ribs	7	12.7%	1.2‰
Lumbar Spine	2	3.6%	0.3‰
Upper Extremity	**15**	**27.3%**	**2,5‰**
Shoulder joint	5	9.1%	0.8‰
Elbow	5	9.1%	0.8‰
Hand and finger	3	5.4%	0.5‰
Clavicle	1	1.8%	0.2‰
Forearm	1	1.8%	0.2‰
Lower Extremity	**15**	**27.3%**	**2.5‰**
Knee'''	12	21.8%	2‰
Ankle	2	3.6%	0.3‰
Groin	1	1.8%	0.2‰

§athletes' exposures. 'Head includes: 3 strangulations, 2 concussions and 3 skin lacerations. ''Face includes: forehead 3, ear 1, eyebrow 4, (all were skin lacerations, rest of the face were unharmed). '''Knee includes 1 knee cup (patellar injury).

Table 4. Type of injuries.

Type of Injury	Number	Injury proportion	Injury incidence rate / AEs§ (6014)
Ligament lesion (6 sprain & 6 rupture)	12	21.8%	2‰
Joint (3 dislocation, 3 subluxation & 6 sprain)	12	21.8%	2‰
Skin laceration	11	20%	1.8‰
Contusion (7 ribs, 1 clavicle, 1 forearm & 1 metacarpal)	10	18.2%	1.6‰
Strangulation (3) and concussion (2)	5	9%	0.8‰
Muscle	3	5.4%	0.5‰
Traumatic bone fracture	1	1.8%	0.2‰
Nerve injury	1	1.8%	0.2‰

§athletes' exposures

Table 5. Severity and Location of injury proportion by Style and by age groups.

Indicators		# Inj 55	# Inj %	Style - #Inj GR*	FS†	WW‡	p-value	Age groups - #Inj Senior	U23	U15	p-value
Severity of injury	moderate	24	43.6%	11	8	5	0.516	6	15	3	0.924
	severe & critical	31	56.4%	10	11	10		10	17	4	
Location of injury	head-and-trunk	25	45.5%	11	13	1	**0.001****	7	16	2	0.590
	upper-and-lower extremities	30	54.5%	10	6	14		9	16	5	

#|Number of injuries, *Greco-Roman Wrestling, †Freestyle Wrestling, ‡Women Wrestling. ** p<0.05

Table 6. Logistic regression.

Severity of injury (reference: moderate)	Variables		OR¶ [95% CI††]	p-value
Severe & critical	Age group	U15/Senior	0.55 [0.06; 4.71]	0.584
		U23/Senior	0.59 [0.15; 2.26]	0.436
	Wrestling style	FS†/WW‡	0.58 [0.11; 3.07]	0.519
		GR*/WW	1.36 [0.23; 8.09]	0.739
	Weight category (kg)		1.00 [0.97; 1.04]	0.783
	Injury location	extremities/head and trunk	4.61 [1.26; 16.92]	0.021**

**p < 0.05. ¶odds ratio. ††95% CI: 95% confidence intervals, *Greco-Roman Wrestling, †Freestyle Wrestling, ‡Women Wrestling

reached the athletic training room (Strauss and Lanese, 1982), or limitations of function to an extent that the athlete sought treatment by an athletic trainer or physician (Lorish et al., 1992; Pasque and Hewett, 2000) or restricted participation of at least one day beyond the initial injury (Kordi et al., 2012).

Another key issue is the location where the documentation is done, which can be recorded during the training, in the competition or at the hospital (Hewett et al., 2005; Otero et al., 2017; Yard et al., 2008). The time frame of data collection is also an important issue, whether it was assembled in one competition, or in a school-year, or life-long in a wrestling club or during a preparation period of a national team (Kordi et al., 2012; Otero et al., 2017; Park et al., 2019; Pasque and Hewett, 2000; Yamaner et al., 2012; Yard and Comstock, 2008). The accuracy of recorded injury data also varies in different studies. Of all the competition data are likely to be the most accurate because they are directly observed and recorded by medical teams (Thomas and Zamanpour, 2018). There are many ways to quantify athletic exposure and no single measure will suit all surveillance settings and research questions. The choice of exposure measures is heavily influenced by sport-specific and contextual factors, as well as which types of health problems are of interest. We adopted the International Olympic Committee consensus statement about exposure measures specifically to wrestling (Bahr et al., 2020).

We examined the direct and indirect contact injuries that occurred during these five international competitions documented by direct observation (Bahr et al., 2020). The wrestling injury rates were 9.1/1000 AEs findings. Kroshus et al. (2018) analyzed 10 academic years where they found a similar injury incidence rate among college wrestlers, but a lesser rate in high school (9.28 versus 2.38/1000 AEs). Thomas and Zamanpour (2018) reported a higher injury incidence rate of 16.3/1000AE for competition studies and 69.5/1000AE for databases. Shadgan et al. (2010; 2017) studied all wrestling injuries that lead to discontinuation of the match in three Olympic Games. The moderate and severe cases from his data accounted for 6 to 12,5 injury incidence rates per 1000 AE from Beijing to Rio Olympic Games.

Regarding the injuries suffered in different styles Shadgan et al. (2017) concluded that during the Rio Olympic competitions the distribution of all wrestling injuries was 40.9% GR, 36.4% FS and 22.7% WW style respectively (Shadgan et al., 2017). Our data shows a similar injury proportion. (Estwanik et al., 1978; Thomas and Zamanpour, 2018; Yard and Comstock, 2008) all reported that GR style had lower injury rates compared to FS; however, the subject populations of those studies were different. Regarding the age groups Strauss and Lanese (1982) studied four wrestling tournaments in grade school, high school and college-age levels and found a 3.8% injury rate among grade schoolboys, who were injured less frequently than high school or college wrestlers (12%). These data also correlate to our findings.

In our study, the injuries of the upper-and-lower extremities were the most common, followed by the head-and-trunk injuries. Hewett and his colleagues (2005) reviewed 10 studies of junior wrestling injuries where the

body region incurring the greatest percentage of injuries was the head/spine/trunk (range of 24.5–48%, average 36.7%), followed by the upper (range of 9.3–42%, average 27.7%) and lower extremities (range of 7.5–45.1%, average 28.75%). Thomas and Zamanpour (Thomas and Zamanpour, 2018) collected data from eight studies. Their results weighed almost the same proportion as we found: 31% head and neck injuries, 25.7% upper extremities, 24.4% lower extremities and 15.4% trunk and spine injuries.

The knee was the far most injured body part by anatomic location in our research as it was in other studies (Jarrett et al., 1998; Kroshus et al., 2018). We found eight head and eight face injuries (21.9% of all injuries). (Kersey and Rowan, 1983) reported that 36.4% of injuries involved the head-face-neck region while Kroshus et al. (2018) reported 21.3% of head and face injuries(Kroshus et al., 2018). The number of rib injuries accounted for 12.7% in our study. Hewett et al. (2005) found rib and chest injuries ranging from 4.1% to 16.1% in different studies, however blunt trauma is difficult to diagnose and treat (Dzsinich et al., 2015). We found an equal number of five injuries in the shoulder and elbow (9.1% of injuries). Different authors reported higher rates of shoulder injuries (3.5 to 24%) and lower rates of elbow injuries (1 to 10.5%) (Agel et al., 2007; Hewett et al., 2005; Kroshus et al., 2018; Pasque and Hewett, 2000; Shadgan et al., 2017). Hand and finger injuries accounted for 5.45% of all injuries in our study, almost the same as Kroshus found (6%) (Kroshus et al., 2018). Ankle and lumbar spine injuries (2 cases each) were accounted for 3.6% in our study, while ankle had a much higher proportion rate in two different studies 7.5% (Agel et al., 2007) and 6.9% (Kroshus et al., 2018)). Lower back injuries varied from 1.2 to 18.6% (Agel et al., 2007; Hewett et al., 2005; Strauss and Lanese, 1982) in three different reviews. In our study, we recorded one injury (1.8%) for each of the clavicle, the forearm and the groin. Hewett et al. (2005) and Agel et al. (2007) ranged pelvis and hip injuries between 1,1-3.2% in their studies. Interestingly, we did not observe any dental injury in our competitions while dental and orofacial trauma is not rare in wrestling (Hewett et al., 2005; Kvittem et al., 1998).

In terms of the type of injuries there were almost equal numbers of ligament lesions, joint injuries, and skin laceration and contusion. Shadgan et al. (2017) reported skin laceration as the most frequent injuries (41%) followed by ligament sprains (13.6%), joint dislocations (13.6%) and contusions (9%) in wrestlers during Rio Olympic competitions. Thomas and Zamanpour (2018) have also reported sprain and strain to be the most frequent injury type with a 37.6% proportion rate which is higher than our findings, followed by laceration, abrasion and contusion which accounted for 23.4% altogether.

We recorded 3 cases of strangulation (5.4%) and 2 cases of concussion (3.6%). Shadgan et al. (2017) reported one case of strangulation injury (4.5%) during the Rio Olympic competitions(Shadgan et al., 2017). Kroshus et al. (2018), and Thomas and Zamanpour (2018) reported a higher rate of concussion (15.9% and 26%, respectively). Prevention of concussion that is due an immediate unintentional action can only be prevented by well-prepared wrestlers, while strangulation injury can be avoided by cautious refereeing (Hewett et al., 2005; Yeo et al., 2020).

Muscle strain and traumatic bone fracture accounted for lesser incidence (5.4% -1.8% respectively) in our cohort while Agel et al. (2007) and Kroshus et al. (2018) reported higher rates of muscle-tendon strain for up to 13.2% -13.3%, respectively. Thomas and Zamanpour (2018) reviewed three articles (Agel et al., 2007; Pasque and Hewett, 2000; Yard and Comstock, 2008) about bone fractures during wrestling competitions and found a 5.8% injury rate.

In our study we observed a wrestler who suffered a strangulation injury followed by temporary paraplegia (nerve injury 1.8%). There are some case reports of spinal cord injuries in the literature, but most of them are cervical spine injuries (Bailes et al., 1991; Boden et al., 2002; Hewett et al., 2005).

We have to emphasize again that this study was only focused on moderate to severe injuries which reached the medical station after the match. In Shadgan et al. (2017) study the majority (55%) of wrestling injuries were mild, 27% were moderate and 18% were severe; no critical injury was observed. While the distribution of moderate injuries in our study differed in the three styles, the same number occurred from severe injuries. The occurrence of moderate and severe injuries was almost the same in Greco-Roman and Freestyle Wrestling, however, it was double in Women wrestling. We recorded one critical injury, which fully recovered without permanent disability.

In connection with different styles the percentage of injuries on the head and trunk was significantly higher in Freestyle Wrestling while the frequency of injuries on the extremities was significantly higher in Women wrestling. Regarding injury severity and injury location there were no significant differences between the different age groups. The analysis of the influencing factors of injury severity (moderate vs. severe & critical) showed that extremity injuries had greater odds of being severe rather than moderate compared to head injuries.

Limitation of this study: although the classification of injury severity, as defined by the UWW-MC, is precise and straightforward, but as this categorization exists only in the UWW Athena and feed-back system. Therefore, it is difficult to compare our data with other studies. There are three more aspects that limit the study: we were focusing on moderate and severe (direct and indirect) contact injuries which occurred during only matches. The documentation and the orientational diagnosis were recorded on-site based on the injury pattern followed by physical examination. We must also state that there were only five International Tournaments organized in Hungary during this period and these five were in different age groups which also complicate a direct comparison.

Conclusion

The primary purpose of this study was to investigate the specifications of contact (direct and indirect) moderate, severe and critical wrestling injuries during a series of UWW Championships by direct observation. This information can help to improve wrestling injury

prevention and enhance medical setup, preparation and coverage of wresting competitions.

Our general injury data registered in UWW competitions correlates with the related literature considering the injuries suffered in match situations or during the competitions.

Despite the relatively low occurrence rate of injuries, there is a need for continuous education for medical teams, referees and coaches to avoid wrestling injuries (Shadgan et al., 2021). One result of this study is that a practical guideline for strangulation (Molnár Sz., 2021) was prepared as a serious preventable injury.

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Key points

- We consider the UWW official classification of the injury severity to be the most straightforward with mild, moderate, severe and critical groups.
- The competition data are likely to be the most accurate because they are directly observed and recorded by medical team.
- One result of this study is that a practical guideline for strangulation was prepared as a preventable serious injury.

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