



Original research

Do riders who wear an air jacket in equestrian eventing have reduced injury risk in falls? A retrospective data analysis

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ABSTRACT

Objectives: To investigate the association between air jacket usage and rider injury severity in equestrian eventing competition falls world-wide.

Design: Retrospective data analysis.

Methods: An analysis was conducted on Fédération Equestre Internationale data for 1819 riders who fell wearing an air jacket and 1486 riders who fell while not wearing an air jacket from 2015 to 2017. Injury data were categorised as either ‘no/slight injury’ or ‘serious/fatal injury’. A *chi*-square test determined whether an association was present between injury severity category and air jacket usage and binary logistic regression determined the effect size of this association.

Results: As a result of falls, 3203 riders sustained no/slight injuries and 102 sustained serious/fatal injuries. While 55.0% of riders who fell were wearing an air jacket, they represented 67.6% of the serious/fatal injury outcomes. Air jacket usage was significantly associated with serious/fatal injuries in falls ($\chi^2 = 6.76$; $p = 0.009$). Riders wearing an air jacket had 1.7 times (95%CI 1.14–2.64) increased odds of sustaining a serious or fatal injury in a fall compared to riders not wearing an air jacket.

Conclusions: Riders wearing an air jacket were over represented in the percentage of serious or fatal injuries in falls compared to riders who only wore a standard body protector. Further research is needed to understand the reason(s) for this finding. It is recommended that additional data on injury outcomes, rider characteristics and the biomechanics of falls be examined in future analyses, and that air jacket and body protector characteristics be further investigated.

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Practical implications

- Riders wearing an air jacket had 1.7 times increased odds of sustaining a serious or fatal injury in a fall compared to riders who only wore a standard body protector.
- There was no evidence that air jackets reduce the risk of rider injury in falls.
- The findings raise questions about the current design of air jackets, their protective benefit, and their recommendation as an injury countermeasure in equestrian eventing.

1. Introduction

In the equestrian sport of eventing, there are high rates of falls and riders can sustain serious or fatal injury.¹ Equestrian and other

equine sports such as horse racing have been highlighted as being more dangerous than motorcycling, automobile racing and other high-risk sports.^{2,3} According to data from the Fédération Equestre Internationale (FEI), the international governing body for the sport of eventing, injury severity in eventing competition has varied based upon the nature of the fall; with serious injuries sustained in one in every 55 falls where only the rider falls, one in every 20 falls where both the rider and the horse fall, and one in every five rotational horse falls.⁴ Rotational falls are generally a result of the horse being somersaulted after impacting a jump obstacle.⁵ The main serious or fatal rider injuries in eventing falls are head injury, spinal injury, and injuries caused by the rider being impacted by a falling horse.^{1,6,7}

The use of personal protective equipment to reduce injury risk has received attention as an injury prevention measure and there are mandatory standards for the wearing of helmets in some equestrian sports.⁸ It has been well established that the use of helmets, while not able to prevent all head injuries, does reduce the risk or severity of head injury in many fall and accident scenarios.^{8,9}

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Table 1

Summary of fall and injury severity statistics in FEI sanctioned competition world-wide from 2015 to 2017.

Year	Starts n	Total falls n	No/slight injury n	Serious/fatal injury n
2015	20,351	1140	1108	32
2016	19,921	1064	1038	26
2017	20,611	1101	1057	44
Total	60,883	3305	3203	102

Table 1 data were obtained from FEI Risk Management Program Statistics 2006 to 2017 (p.21)⁴.

The use of body protectors has also been implemented as an injury prevention measure, having been mandated in racing and some equestrian sport disciplines.^{10,11} The reported benefits of body protectors are that they provide some protection to the torso from impacting the ground or hard objects, as well as providing some protection if the rider is kicked or trampled.¹⁰ However, the benefits of body protectors have not been as well established as helmet usage, nor are they well supported by reduced injury outcomes data.^{12–14} The characteristics of body protectors that provide the best safety benefit is an area of on-going research and development.^{15,16}

Since approximately 2010, air jackets (also known as air vests or airbag vests), originally developed for motorcyclists, have been used in equestrian sports.^{17,18} The use of air jackets is prevalent amongst riders participating in eventing;¹⁹ however, in the cross country phase, riders must still wear a standard body protector if they also choose to wear an air jacket.⁵ Air jackets are designed to deploy when a lanyard attached to the saddle disengages from the air jacket, activating a CO₂ cartridge which subsequently inflates the air jacket.¹⁷ Sometimes they fail to deploy before the rider impacts the ground.^{20,21} Once inflated, an air jacket provides additional impact protection to the torso^{5,18} (and in some models neck protection) compared to standard body protectors. However, there have been contradictory reports regarding the safety benefits of air jackets and concerns have been raised about the effect on riders' ability to *tuck-and-roll* while wearing an inflated air jacket.²² A study of 62 cross country falls reported no significant difference in injury outcomes for riders wearing an air jacket compared to riders who were not wearing an air jacket.²⁰

With contradictory claims and concerns in mind, the objective of this study was to investigate the association between injury severity and air jacket usage in eventing competition falls from 2015 to 2017 using the FEI recorded statistics and reports.

2. Methods

Data on competition starts, falls and injury outcomes is collected from FEI sanctioned competitions conducted by national member bodies. This information is publicly available via the FEI website.²³ Fall injury severity in the FEI data was reported as no injury; slight injury; serious or fatal injury. Rider injury severity was confirmed by the Chief Medical Officer at the event and further information was requested from the national federation where the injury was recorded as serious or unknown;²⁴ however, no precise definition of the types of injuries included in each injury severity category were provided in the reports. Since 2015, the FEI has also reported data on fall injury severity with and without air jacket usage.²⁵

From the published FEI injury statistics,⁴ a table was compiled recording competition starts, falls with no/slight injury, serious/fatal injury and total falls for each year of the study period (Table 1). From the original reported data, the number of falls with no injury and slight injury were combined to obtain (n) for an aggregated no/slight injury category, because the available data

Table 2

Injury severity in falls with and without air jackets in FEI sanctioned competition world-wide from 2015 to 2017.

Year		No/slight injury		Serious/fatal injury		Total falls	
		n	%	n	%	n	%
2015	Air jacket	588	53.1 ^a	20	61.0 ^a	608	53.3
	No air jacket	520	46.9	12	39.0	532	46.7
	Sub-total	1108	100.0	32	100.0	1140	100.0
2016	Air jacket	618	59.5	20	77.0 ^b	638	60.0 ^b
	No air jacket	420	40.5	6	23.0	426	40.0
	Sub-total	1038	100.0	26	100.0	1064	100.0
2017	Air jacket	544	51.5	29	66.0 ^b	573	52.0 ^b
	No air jacket	513	48.5	15	34.0	528	48.0
	Sub-total	1057	100.0	44	100.0	1101	100.0
2015–2017	Air jacket	1750	54.6	69	67.6	1819	55.0
	No air jacket	1453	45.4	33	32.4	1486	45.0
	Total	3203	100.0	102	100.0	3305	100.0

Sub-total and Total (n) were obtained from Table 1.

The remaining (n) and % in Table 2 were calculated from other data in the table.

^a Obtained from the 2016 Seminar Report (p.4)²¹.

^b For 2016 the percentages were obtained from the Summit Report (p.21)²², and for 2017 the percentages were obtained from a Seminar Report (p.3)²⁶.

only allowed air jacket statistics to be calculated for this combined category for 2016 and 2017.

A second table compiled data to identify rider injury severity statistics with and without air jackets (Table 2), using (n) from Table 1. For 2015, the percent of riders who fell wearing an air jacket were reported separately for serious/fatal injury, for no injury and for slight injury.²¹ These percentages were used to calculate the aggregated no/slight injury values and the total falls with and without air jacket usage for 2015.

For the years 2016 and 2017, the percentage of riders who fell wearing an air jacket were reported only for serious/fatal injury and for total falls.^{22,26} Serious/fatal injury was subtracted from total falls to obtain the no/slight injury values with and without air jacket usage for 2016 and 2017.

The expected number of injuries for rider falls with and without air jackets were calculated as the total number of falls from each injury severity category multiplied by the percentage of riders in each air jacket category. A *chi-square* test (X^2) determined whether there was an association between air jacket usage and injury severity category by comparing observed injury outcomes with expected injury outcomes (Table 3). Binary logistic regression then determined the magnitude of effect of injury severity for riders wearing an air jacket relative to riders not wearing an air jacket. Analysis steps were performed using Minitab 16, with a significant p-value of <0.05 set for X^2 and a 95% confidence interval (CI) for the odds ratio.

3. Results

For the three-year study period, the FEI reported 60,883 rider competition starts and 3305 falls (Table 1); a fall rate of 54.3 falls per 1000 starts. There were 3202 falls where no/slight injuries were sustained, and the 102 serious/fatal injuries sustained by riders represented 3.1% (102/3305) of falls.

While 55.0% (1819/3305) of riders who fell were wearing an air jacket, they represented 67.6% (69/102) of the serious/fatal injury outcomes (Table 2). Conversely, riders who fell while not wearing an air jacket represented 45.0% (1486/3305) of the falls but only 32.4% (33/102) of the serious/fatal injuries.

The numbers of serious/fatal injuries were greater than expected for riders wearing an air jacket and less than expected for riders not wearing an air jacket ($p = 0.010$). There was, however,

Table 3
Association between injury severity in falls and air jacket usage in FEI sanctioned competition world-wide from 2015 to 2017.

	No/slight injury n	Serious/fatal injury n	Total n	Odds ratio of serious/fatal injury n (95% CI)
Air jacket				
Observed	1750	69	1819	1.7 (1.14–2.64)
Expected	1763	56	1819	
No air jacket				
Observed	1453	33	1486	0.6 (0.38–0.88)
Expected	1440	46	1486	
Total	3203	102	3305	

no significant difference ($p = 0.648$) in the no/slight injury category based on air jacket usage (Table 3).

The *chi*-square test identified a significant association ($\chi^2 = 6.76$; $p = 0.009$) between air jacket usage and injury severity category in falls. Binary logistic regression identified that riders wearing an air jacket had 1.7 times (95%CI 1.14–2.64; $p = 0.010$) increased odds of sustaining a serious or fatal injury in a fall compared to riders not wearing an air jacket (Table 3).

In correspondence with FEI, the FEI advised that in 443 (13%) of the 3305 cases, the question in the fall report, “Was an Air Jacket worn?” remained unanswered. These cases were deemed to be for riders who were not wearing an air jacket and included in reporting as being in the “No air jacket” category. To test the effect of this assumption, a further analysis was performed with these cases removed. The revised analysis produced no appreciable change to findings ($\chi^2 = 6.11$; $p = 0.01$); with riders who wore an air jacket having 1.8 times (95%CI 1.13–2.98; $p = 0.01$) increased odds of sustaining a serious or fatal injury from a fall compared to riders not wearing an air jacket. As missing data made little difference to the results, these cases were treated in accordance with the published FEI reports and thus remained in the analysis.

4. Discussion

A prior study on the effectiveness of air jackets in falls during the cross country phase of eventing reported no significant difference ($p = 0.657$) in injury outcomes, with 13.7% (7/51) of serious injuries sustained by riders who wore an air jacket and 9.1% (1/11) of serious injuries sustained by riders who did not wear an air jacket.²⁰ Serious/fatal injuries sustained by riders in our study were 3.8% (69/1819) for riders wearing an air jacket and 2.2% (33/1486) for riders not wearing air jacket (Table 3). The inclusion of falls in all eventing disciplines, and not just the cross country phase of eventing, may explain the lower fall percentages in our study. The significant difference in serious/fatal injury outcomes based upon air jacket usage found in our study, compared to no significant difference being reported in the prior study, may be explained by the large difference in sample sizes. Other studies have reported increased impact absorption properties of air jackets when compared to traditional body protectors in a laboratory setting.^{5,18} These studies did not, however, include data on injury outcomes for riders who fell from their horse.

Our study included a large sample size of 3305 falls and 102 serious/fatal injury outcomes. An improved procedure to obtain more reliable information on injury severity has been implemented by the FEI since 2010.^{4,24} Since 2010, injury severity has been confirmed by the Chief Medical Officer at the event and further information requested from the national federation where the injury classification was reported as either unknown or serious. There may be differences in how slight and serious injuries were reported by member nations, indicating the need for further and more defined categorisation of injuries.^{21,26} While possible differences in the classification of slight and serious injury is a limitation, there was no suggestion in the FEI reports that differences in injury

classification by national federations were based upon air jacket usage.

The available data only enabled investigation of the association between air jacket usage and injury severity and not the reason(s) for the association. Therefore, the significant association does not necessarily mean that air jackets are the cause of increased serious/fatal injuries. Further investigation is required to understand the reason(s) for the association.

A number of explanations for the significant association between air jacket usage and increased serious/fatal injury in falls are plausible. Independent testing of five different equestrian air jacket products, popular on the Swiss market, reported that pull forces of between 150 and 593 Newtons were required to deploy air jackets.¹⁸ It is possible that the pull force applied to riders may alter their fall trajectory, increasing the risk of landing closer to the horse, and thereby increasing the risk of crush or trampling injury. Whether riders wear an air jacket or only a standard body protector, there is a high risk of serious/fatal injury when the horse lands directly on the rider.^{5,27}

Upon deployment, air jacket airbags inflate along the longitudinal axis of the torso which may restrict the rider’s torso movement and impede their ability to *tuck-and-roll* following ground impact. Laboratory testing of body protectors and air jackets have focussed on their impact absorption characteristics measured by vertical drop testing.^{5,18,27} Fall scenarios in equestrian sports vary, and are often more complex than a vertical fall in an extended prone or supine position without any horizontal component of velocity.²⁸ Measures of longitudinal bending stiffness²⁹ and the areas of anatomy that are covered, for both standard body protectors and air jackets, should be included in future analyses to determine if these factors are associated with injury severity and/or incidence of injury.

A further explanation for the association between air jacket use and fall injury severity may relate to the sound level from activation of the CO₂ cartridge. As activation acoustic level is in the range of 87 to 98 dB(A),¹⁸ this may elicit an involuntary startle response in humans,³⁰ momentarily distracting the rider from responding to the impending fall.

While it remains a possibility that rider characteristics may be a factor contributing to the rate of serious injuries associated with air jacket use, a reported analysis of international eventing competition data from 2015 indicated no correlation between the use of air jackets and rider experience.²¹ Further, FEI reported the number of falls as a percentage of starters for each level of competition from 2014 to 2017 to be 4.8% for one-star competitors, 5.4% for two-star, 6.8% for three-star, and 13.3% for four-star.⁴ This rising rate of falls as competition level increased suggests that falling is not only associated with lower rider skill. It remains a possibility that riders who are at a greater risk of injury may be more likely to wear an air jacket; however, without further research, there is no data to test this hypothesis.

Further research is warranted to determine causative factors for the identified association between air jacket use and serious/fatal injury rate and, if necessary, to investigate possible means to atten-

uate risk. It would be beneficial to include additional data on the relationship between air jacket usage and the level of competition, event, horse and rider characteristics, the biomechanics of falls, injury mechanisms and the exact nature of injuries sustained in future analyses. Data should also be included on the brand and model of body protectors and air jackets worn, including measures of longitudinal bending stiffness, anatomy coverage, air jacket activation acoustic level, and impact absorption characteristics. The effect of lanyard pull forces on rider fall trajectory could also be assessed. Future analyses could then be conducted with more comprehensive datasets in a multivariable model that include effect modifiers.

5. Conclusion

Riders wearing an air jacket were over represented in the percentage of serious/fatal injuries in FEI eventing competition falls compared to riders who only wore a standard body protector. There was no evidence that riders who wore an air jacket had reduced injury outcomes in falls.

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