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Retrospective study of Parajump injuries in Indian Armed Forces

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ABSTRACT

Introduction: A number of studies on military and civil parachuting injuries have been published in the past. Most of the studies place the incidence of parachuting injuries to vary between 0.22% and 0.89%. The profile of injuries sustained during jumps by Indian paratroopers from Paratrooper Training School (PTS), Agra, between 2013 and 2019 was analyzed.

Material and Methods: A retrospective analysis of Indian military parachuting injuries was done to assess injury patterns from the records of static line and combat free fall jumps, available at the PTS. The data pertaining to 270 injuries sustained from 256 jumps were analyzed in terms of number of jumps by each paratrooper, type of course/ mission, age, time of the of jump (day/ night), type of parachute used, wind speed at the time of drop, terrain on which the paratrooper landed, the location / part of body injured, the diagnosis, and finally the possible modality of injury using descriptive statistics.

Results: The incidence of injuries ascertained from the records varied from 0.054% to 0.10% with a mean incidence of 0.083% from 306,986 jumps recorded over 7 years. Most injuries were related to refresher jumps and static line jumps. There were three fatalities recorded in this period, all due to failure of main and standby parachutes. Most of the injuries were sustained at the time of landing (218, 86.17%). Lower limb injuries accounted for maximum injuries (109, 40.37%), followed by truncal injuries 95 (35.19%) and upper limb injuries 33 (12.22%).

Conclusion: The study brings out an interesting aspect of significantly less military parachuting injuries seen in the present study vis-à-vis reported in literature. A high degree of physical fitness and rigorous training are probably responsible for this low incidence. Increasing the duration of refresher training and physical conditioning may further reduce the occurrence of injuries. A cost-efficacy analysis of the same may be done before effecting changes in the training programme.

Keywords: Paratrooper, Parachute, Static line, Free fall, Injuries

INTRODUCTION

A parachute is a device used to slow the motion of an object through an atmosphere by creating drag.[1] Any fall assisted or unassisted, even from smallest heights, is riddled with the possibilities of injuries. This has been known since the invention of the parachute way back in the Renaissance period.[2] The modern-day parachute, much like the ones used by militaries across the globe, was invented in the late 18th century by Louis-Sébastien Lenormand in France. He made the first recorded public jump in 1783. Two years later, in 1785, Lenormand coined the word "parachute" by hybridizing an Italian prefix para, an imperative form of parare, "to avert, defend, resist,

guard, shield, or shroud," from paro, "to parry," and chute, the French word for fall, to describe the aeronautical device's real function.[3]

Conventionally, the term "paratrooper" refers to a military parachutist. Paratroopers jump out of airplanes and use parachutes to land safely on the ground.[4] The first extensive use of paratroopers was by the Germans during World War II. Since then, military parachuting is practiced as a fast and effective way of strategic deployment of troops.[5,6] To achieve the best during operations, military parachuting involves intensive training and regular practice jumps. However, all aspects of parajumping, i.e. from jumping out of an aircraft, opening or deployment of parachute canopy, and landing, have injury potential and make the parajumper vulnerable to various spectra of injuries.

Parachuting injuries as can be ascertained by the process of parachuting can occur during exit from aircraft (fouling or collision with aircraft structures), the parachute opening shock, leading to sudden decelerative forces causing jolt to body parts in contact with the harness, or late/non-deployment of parachute or from uncontrolled landing speed/direction and due to incorrect posture assumed on touchdown. Injuries may also result from induced "leap frogging," or uneven weight-bearing, namely, landing on toes or single foot. However, most injuries are related to landing posture/techniques and are deemed to be preventable. Having said that, it is but natural for the very healthy and highly motivated personnel be selected for parajumping. A study by Bricknell brought out that "infantry in receipt of parachute pay is relatively more healthy than other soldiers."[7] The paratrooper training itself ensures high degree of physical fitness in the volunteers.

The Paratrooper Training School (PTS) of Indian Air Force has been conducting the basic and refresher training for the three services now for more than 45 years. As per records, on an average, 45,000 jumps are conducted annually. A number of retrospective and prospective studies have been published in the past few decades on the numbers and incidence of injuries resulting from parachuting. These include both military and civil jumps.[8-11] However, similar studies in the Indian scenario are scant, and hence, study of parajump injuries in Indian Armed Forces was the desired objective.

MATERIAL AND METHODS

The study involved a retrospective analysis of paratroopers' jumps for a period 7 years from the year 2013 to 2019 at the PTS. The injury data were collected from the paratroopers' records maintained at the school. The study primarily involved analyzing the injuries sustained. However, the denominators for the details such as type of para used, time of jump, and terrain were not available for the jumps other than recorded in the injury data (jumps in which an incident report was raised). Confidentiality of paratroopers' identity was maintained and Institute Ethics Committee clearance was obtained. The records contained details of the number of jumps by each paratrooper, type of course/mission, age, time of the of jump (day/night), type of parachute used, wind speed at the time of drop, terrain on which the paratrooper landed, the location/part of body injured, the diagnosis, and finally the possible modality of injury. Since the study was retrospective and involved in depth study of more than 700 incident forms, only descriptive analysis could be done in the absence of denominators.

RESULTS

A total of 3,06,986 jumps were made in the 7 years period of study that included basic training, refresher courses, and exercises. Annual distribution of the number of jumps per year in this period with the number of jumps involving injuries is presented in [Table 1]. It can be inferred from the table that a total of 256 jumps resulted in injuries with a prevalence rate of 0.08%. A total of 270 injuries were sustained indicating that some jumps resulted in multiple injuries.

Training course-wise distribution of these 256 jumps in which injuries were recorded is presented in [Table 2]. Most injuries were sustained during refresher jumps (67.58%). This was followed by basic training jumps (17.97%) and exercise jumps (13.67). The injury rate was lowest among staff jumps (0.78%).

Table 1: Year-wise data of jumps and injured.

S. No.	Year	No. of jumps	No. of injured	% injured
1.	2013	42,261	23	0.054
2.	2014	40,574	38	0.094
3.	2015	44,327	43	0.097
4.	2016	44,756	31	0.069
5.	2017	43,992	38	0.086
6.	2018	46,041	46	0.100
7.	2019	45,037	37	0.082
	Total	306,986	256	0.083

Table 2: Training course-wise distribution of jumps resulting in injuries.

S. No.	Training course	No. of jumps	% of total
1	Basic (beginners)	46	17.97
2	Exercise (trained)	35	13.67
3	Refresher (trained)	173	67.58
4	Staff (parajump instructors)	2	0.78
	Total	256	100

Table 3: Modalities/factors causing injuries during parajumps.

S. No.	Modality of injury	No. of cases (%)	Type of injury	Remarks
1.	Aircraft structure	12 (4.69)	Contusions/sprains	Hit Aircraft structure at the time of exit
2.	Aircraft static line	2 (0.78)	Burns/lacerations	Friction burns with static line affixed in aircraft
3.	Collapse of parachute canopy	3 (1.17)	Strains/sprains//fractures	Wind steal effect
4.	Dragged by parachute on ground	3 (1.17)	Contusions/lacerations/ bruises	Ground contact injuries
5.	Failure of parachute to deploy	3 (1.17)	Fatalities	Hard impact on ground
6.	Fall after landing	11 (4.30)	Sprains/fractures	Unbalanced touch down
7.	Fall in water	2 (0.78)	Blunt injuries/contusions	Water impact
8.	Leap frogging while landing	11 (4.30)	Strains/sprains/contusions	Multiple impacts
9.	Hard impact	9 (3.52)	Strains/sprains/contusions/ fractures	Undulating hard ground
10.	Helmet harness	1 (0.39)	Soft-tissue injuries	Wind shear
11.	Mid-air collision	3 (1.17)		With other paratroopers
12.	Improper landing posture	176 (68.75)	Sprains/strains/fractures	Toes pointing down or one leg landing/ landing on back
13.	Late deployment of para	1 (0.39)	Harder impact	Operation of secondary/emergency parachute
14.	Leg entangle in lines	2 (0.78)	Lacerations/sprains	Spinning on exit/at the time of para opening
15.	Loose thigh strap	1 (0.39)	Testicular injury	Loose harness impacting at the time of para opening
16.	Rigging line	1 (0.39)	Friction burns	Body parts entangling in rigging lines at the time of deployment
17.	POS	8 (3.13)	Fractures/dislocations	Shock caused by sudden arrest of free falling trooper by deployment of parachute
18.	Para spiraling	1 (0.39)	Fracture	Uncontrolled landing
19.	Hypoxia	3		HAA jumps
20.	Unknown	2		Cause could not be ascertained
	Total	256		

POS: Parachute opening shock

Table 4: Distribution of injuries during various phases of parajump.

S. No.	Phase of jump	No.	%
1.	Aircraft exit	14	5.53
2.	Mid-air	21	8.30
3.	Landing	218	86.17
	Total	253*	100.00

*Fatalities excluded

Table 5: Distribution of injured based on landing terrain.

S. No.	Landing terrain	No.	%
1.	Grassy land/bushes	2	0.78
2.	Hard plains	17	6.64
3.	Soft undulating ground	1	0.39
4.	Hard undulating ground	16	6.25
5.	Soft mud/sand	217	84.77
6.	Water	2	0.78
7.	Wires	1	0.39
	Total	256	100.00

The factors/modalities involved in the process of parachuting vis-à-vis details of injuries are presented in [Table 3]. The distribution of injuries in different phases of parachuting and that based on landing terrain are presented in Tables 4 and 5, respectively. Landing injuries formed the bulk of the injuries accounting for 218 out of the 253 descents (three fatalities excluded). This amounted to 86.17% of the total injuries sustained by paratroopers. Injuries sustained while exiting the aircraft accounted for 14 (25.53%) while the injuries sustained in mid-air were 21 (8.30%) due to mid-air collisions, entangling of the rigging lines with the paratroopers or caused by parachute opening shock (POS) (cervical whiplash and shoulder dislocations/clavicular fractures).

A total of 217 injuries (84.77%) were sustained while landing on the standard training drop zone. This is a soft tilled field. Broadly, two main types of parachutes were used, the ram-air type for combat free falls and static-line variety for basic and

refresher training. The distribution of injuries based on these two types of parachutes is presented in Table 6. Static-line type parachute was associated with 219 (85.53%) injuries. 46 of the 256 paratroopers sustained injuries during night jumps, the remaining 210 sustained during clear day.

A total of 293 musculoskeletal injuries were noted in this study accounting to 90% of the total injuries sustained. The details are presented in Table 7. The most common types of injuries were fractures, sprains/strains, and contusions accounting for 33.70%, 28.15%, and 15.93%, respectively. Ninety-one fractures (33.70%) were recorded and 25 dislocations (9.26%) occurred out of which 80% were shoulder dislocations and 12% were knee dislocations.

Ninety-five (35.19%) injuries were over the trunk of which 86 (31.85%) of injuries were sustained in lumbosacral region. A total of 109 (40.37%) injuries were identified in lower limbs. Of these, ankle injuries accounted for 47 (17.41%) followed by 27 knee injuries (10%) and 23 leg injuries (8.52%). Head-and-neck injuries were 21 (7.78%) while upper limb injuries were 33 (12.22%) with shoulder being the commonest site of affliction as part of mid-air injuries due to POS (24, 8.89%). The most common site of injury was over the lower back or lumbosacral region. This accounted for 86 (31.85%) injuries.

Table 6: Distribution of Injuries depending on type of parachutes.

S. No.	Parachute type	No.	%
1.	Ram-air	37	14.45
2.	Static line	219	85.55
	Total	256	100.00

The other common sites were ankle, knee, and shoulder accounting for 47, 27, and 24 injuries, respectively (17.41%, 10%, and 8.89%).

DISCUSSION

Incidence of injuries in militaries has been documented to range from 0.22% to 0.89% in literature during the period of 1975–2000.[8,12-16] Cilli *et al.* (2006) studied 43,690 military paratroopers in Turkey, including static-line and free fall military jumps.[17] They reported 8.07 injuries per 1000 aircraft exits consistent with previously reported injury rates for military parachuting. Our finding of incidence of parachuting injury varying from 0.054% to 0.1% with a mean incidence of 0.083% is almost one-tenth of what is reported from other studies. This can probably be attributed to the rigorous training and high physical fitness standards used for the selection of paratroopers in Indian military. Most of the injuries sustained are associated with refresher jumps. While paratroopers undergoing basic course undergo a 15-day physical conditioning and training schedule, those coming for refresher course only do 2 days of training. This along with complacency coming from previous experience may account for the high number of injuries.

Ekeland (1997) and Cilli *et al.* (2006), in consonance with other earlier studies, found that incidence of injury in static line jumps was significantly higher than in free fall category. Our study showed similar findings with 85.55% injuries sustained during static-line jumps. Bricknell and Craig (1999) have described the mechanism of mid-collisions occurring among the troopers. He also described landing injuries by

Table 7: Distribution of musculoskeletal injuries sustained.

S. No.	Injured body part	Type of injury				Total
		Contusion	Strain/sprain	Fracture	Dislocation	
1.	Skull	8	–	2	–	10
2.	Cervical	–	2	1	–	3
3.	Shoulders	2	–	2	20	24
4.	Chest	4	–	–	–	4
5.	Dorsal spine/upper back	2	–	–	–	2
6.	Arm	–	–	1	–	1
7.	Elbow	1	–	–	1	2
8.	Hand	1	1	3	–	5
9.	Lumbosacral/low back	16	49	21	–	86
10.	Pelvis	–	–	–	1	1
11.	Thigh	–	–	3	–	3
12.	Knee	5	17	2	3	27
13.	Leg	–	1	22	–	23
14.	Ankle	3	9	35	–	47
15.	Foot	1	–	4	–	5
	Total	43	76	91	25	243
	% of total (270) injuries	15.93	28.15	33.70	9.26	90.00

virtue of wrong position assumed by the paratrooper, either due to toes pointing downwards at the time of touch down or position of legs (feet wide apart), leading to one foot touching down earlier than the other and causing full weight transmission to that leg causing stress/strains and fractures.[5] Landing on buttocks leading to fractures of coccyx, fractures of pelvis and thigh bones have been described. He described the mechanism of backward head jerking being responsible for whiplash injuries of the neck or closed head injury if the helmet struck the ground hard as a result of whiplash. Our findings are in consonance with the studies on military jumps over the past four decades.

Lord and Coutts published a study on parachuting injuries in 1944. They analyzed data from 250,000 jumps at the Parachute School, US and suggested that statistically, any parachutist had only 1% chance of injury in any one parachute descent, and this figure was decreasing. They also suggested that some typical medical parachute entities, namely, strain of the right rectus muscle, contusions, and separations of the acromioclavicular joint, fracture of the lower third of the fibula associated with fracture of the posterior tibial lip, the "silent fracture" of the upper third of the fibula, and less frequently a dislocation of the fibular head were common. The fibula may be fractured in its upper third and be relatively asymptomatic; hence, the designation "silent fracture" was chosen by them. They also suggested that both feet held together on contact with the ground, replacing the old method of holding the feet 18 inches apart on landing, markedly reduced ankle fractures.[18]

Bricknell, in his comprehensive review of 10 studies in 1999, included both military and civilian jumps. The regional distribution of parachuting injuries, from these jumps discussing the military parachuting injuries,[12,15,16,19-21] revealed that a substantial proportion of injuries was sustained in the back followed by leg including ankle. These were followed by head and shoulder injuries. In the present study, the most common site of injury was over the lower back or lumbosacral region. This accounted for 86 (31.85%) injuries. The other common sites were ankle, knee, and shoulder accounting for 47, 27, and 24 injuries, respectively (17.41%, 10%, and 8.89%). While, Ellitsgaard (1987) reported maximum injuries to ankle (65, 37%) out of 176 injuries studied in 110,000 sports jump followed by spine injuries 18 (10.22%) and wrist injuries 17 (9.65%),[10] Vincent *et al*. (2014) analyzed 110 military paratrooping injuries from Madigan Army Medical Center emergency department from February 2005 to June 2011. They reported 71 (65%) lower extremities injuries vis-à-vis 23 (22%) head injuries followed by 22 (19%) injuries involving neck spine and back injuries and 21 (19%) upper extremities injuries.[22] In the present study, if all the lower extremity injuries are clubbed, they amount to a figure of 109 (43.7%) of which 105 (38.89%) were musculoskeletal injuries, much in line with other studies including the one by Vincent *et al*. who also reported lower limb injuries contributing maximum to the total. This is followed by spinal injuries (89, 32.96%) and upper extremity injuries (32, 11.85%) [Table 7].

This is probably the first study in the recent times documenting injuries associated with parajumping in India. It is presumably, also the study involving largest numbers of jumps as far as could be found from the past and extant literature. However, the study was retrospective based on the available records, and hence, the findings are limited to descriptive analysis. Nevertheless, the study is considered informative and operationally relevant.

CONCLUSION

Analysis of 3,06,986 parajumps undertaken over a period of 7 years revealed a mean incidence of injuries of 0.083% which is almost one-tenth of that reported from other studies. A high degree of physical fitness and rigorous training is probably responsible for this low incidence. Most injuries were related to refresher jumps and static-line jumps. The lumbosacral spine was the most common site of injury followed by the ankle, knee, and shoulder. Fractures are the most common type of injury sustained. Increasing the duration of refresher training and physical conditioning may further reduce the occurrence of injuries. A cost-efficacy analysis of the same may be done before effecting changes in the training program.

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Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

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