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Assessment of fatigue among aircrew of Bangladesh air force using multidimensional fatigue symptom inventory-short form

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Abstract

Background: Whether arising from operational obligations or other factors, fatigue poses a significant and immediate threat to combatants in general and military pilots specifically. The most serious problem is the possibility of performance decrement as a direct consequence. The fatigue level among the aircrew of Bangladesh Air Force (BAF) is yet to be measured. This study was designed to evaluate the fatigue level present among the aircrew and a comparison with ground support personnel.

Materials and Methods: This cross-sectional study was conducted in the Medical Squadron of BAF Base Bashar (Flight surgeon office), Dhaka from December 2024 to March 2025. Multidimensional Fatigue Symptom Inventory- short form, comprising thirty questionnaires served as the tool for the purpose of this research. 120 aircrew and ground support members of either sex were selected randomly from various air bases for this research.

Results: The levels of fatigue among the personnel were statistically significant, with 50% of the transport aircrew, 33.33% of the fighter aircrew, 46.47% of the helicopter aircrew, 81.81% of the air traffic control (ATC) personnel and 63.63% of the other ground support personnel are experiencing it. ATC and ground support personnel group exhibited a substantially higher level of total fatigue in all of its subscales (general, physical, emotional, and mental with the exception of vigor than the aircrew group. The pilots of different types of aircraft were similar to one another regarding their overall fatigue scores.

Conclusion: This study highlights the significant prevalence of fatigue among both aircrew and, notably, ground support personnel within the BAF. Ground support staff and ATC personnel demonstrate higher fatigue levels than aircrew, challenging existing perceptions. Younger, less experienced pilots also show increased susceptibility. Implementing structured duty-rest cycles and targeted interventions remains paramount to safeguarding operational effectiveness and ensuring the well-being of the entire force.

Keywords: Aircrew, multidimensional fatigue symptom inventory-short form, Bangladesh Air Force

Introduction

Although fatigue plays a major role in the causation of aircraft accidents, the percentage of accidents attributable to fatigue remains uncertain.[1] It is estimated that fatigue may be the causative factor in 4–7% of civil aviation accidents.[2] In military scenarios, the percentage of aircraft accidents arising from fatigue is not available in an open forum due to the sensitive nature of

such information. However, a study by the USAF safety center states that 25% of the USAF's tactical fighter class accidents between 1974 and 1992 were attributable to fatigue and 12.2% of the USN accidents from 1977 to 1990 were fatigue-related.[3]

Causes of human fatigue, including insufficient sleep, interruptions to the body's natural rhythm, health problems, and job-related factors, can adversely affect decision-making capabilities, memory performance, judgment skills, reaction speed, and awareness in aviation operations.[4]

Progress in technology and engineering keeps improving safety in military aviation, resulting in major decreases in incidents over the decades. Regrettably, numerous notable issues in aviation remain problems that have persisted for years despite extensive research endeavors in these fields.[5,6]

Fatigue can be difficult to investigate in naturalistic settings due to the numerous factors that affect both sleep quality and quantity. It is especially arduous to examine fatigue and its contribution to accidents since variables, such as hours slept are often self-reported, if reported at all, after an event, and are therefore prone to individual bias.[7] Moreover, self-reported sleep after an event may not be entirely accurate in an attempt to shift the liability for the accident away from the individual out of fear of repercussions. Therefore, assessing sleep outside of accidents and incidents may offer valuable insight into the quantity and quality of sleep that aviators receive. In addition, while fatigue poses risks in any military context, it carries particular significance in aviation operations where even a momentary lapse in attention or decision-making can lead to expensive mistakes with minimal time available for correction.[8] Furthermore, recent studies have begun to explore and compare fatigue levels specifically between military pilots and air traffic controllers (ATC).

Materials and Methods

A cross-sectional observational study was conducted in the Medical Squadron of Bangladesh Air Force (BAF) Base Bashar, Dhaka, from December 2024 to March 2025. Multidimensional Fatigue Symptom Inventory-Short Form (MFSI-SF), comprising thirty questionnaires served as the tool for the purpose of this research. The study protocol was approved by the ethical review committee for medical research of the BAF. The MFSI-SF, which is comprised of 30 questionnaires, was implied for the study. A total number of 87 aircrews from different streams (fighter, helicopter, and transport) and 33 ground crew, including ATC of either sex were selected randomly and were requested to answer 30 questionnaires regarding the various symptoms they had encountered in the preceding week, along with their intensity. This survey was executed in a staged manner, encompassing both aircrew and ground support personnel. The participants were requested to respond to 30 items in the survey, considering various symptoms experienced in the preceding week. The severity of various symptoms was assessed using a 5-point Likert scale (0 = not at all; 4 = extremely). Scores for five subscales (general, physical fatigue, emotional fatigue, mental fatigue, and vigor) were derived by summing the ratings. The total score was determined by aggregating the values from the general, physical, emotional, and mental subscales and subtracting the vitality subscale score. The total MFSI-SF score ranged from −24 to 96, with a cutoff score established at 24. Elevated scores indicated an increased level of weariness.

The statistical assessment was performed using Microsoft Excel and Statistica (version 25). The data were conveyed as mean ± standard deviation. The data exhibiting a normal distribution was analyzed using a *t*-test. The data that deviated from normal distribution was analyzed using non-parametric statistical tests (Chi-square, Mann–Whitney U-test).

Results

(Applying the threshold score of 24 for cumulative fatigue in the MFSI (SF), 43 out of 87 aircrews and 23 out of 33 ground support personnel were

classified as "personnel with fatigue," while the remaining 54, comprising 44 aircrews and 10 ground support personnel, were categorized as "personnel without fatigue." The computed Chi-square statistic was 3.97 with $P = 0.04$ (Significant at $P < 0.05$). The results demonstrated that ground support personnel exhibited a markedly greater percentage of weary persons compared to the pilot group (69.69% vs. 49.43%) [Figure 1]. A total of 120 personnel from different BAF bases participated in this cross-sectional survey. Table 1 illustrates the details of demographic details alongside the participants' experience level and period of service. The Mann–Whitney U-test and Chi-square tests indicated a statistically significant variation in age, period of service, and marital status (married/single ratio) but no significant variation in sex (male/female ratio) between the aircrew and ground support personnel [Table 1]. The mean age and duration of service were lower in the aircrew group compared to the ground support personnel. Of the 87 aircrew participants, 33 (37.93%) were helicopter crew, 30 (34.48%) were fighter pilots, and 24 (27.59%) were transport crew. Among the 33 ground crew, 11 (33.33%) were from ATC, while 22 (66.67%) were other ground support personnel. It was determined that 18 of 33 helicopter crew members, 14 of 30 fighter crew members, 10 of 24 transport crew members, 9 of 11 ATC personnel, and 14 of 22 other ground support personnel displayed indications of weariness. The Chi-square value was 4.3722 with $P = 0.03$ (significant at $P < 0.05$), showing the following proportions of personnel suffering fatigue: 54.55% of the helicopter crew, 46.67% of fighter pilots, and 41.67% of transport crew. Among 33 ground personnel, 81.81% of ATC personnel and 63.63% of other ground people were statistically significant [Figure 2]. The one-way analysis of variance [Table 2] revealed a statistically significant difference ($P < 0.05$) in total fatigue scores among the various personnel groups, indicating that at least one group differed significantly from the others. To pinpoint these specific differences, a Tukey-Kramer honestly significant difference *post hoc* test [Table 3] was conducted. This analysis showed no significant

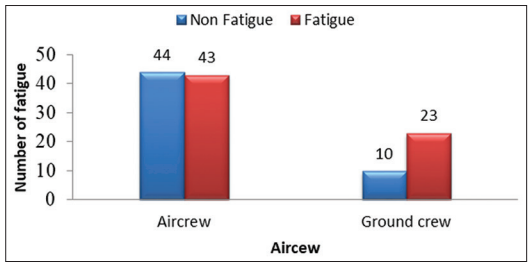

Figure 1: Aircrew and ground support personnel having fatigue scores more than 24

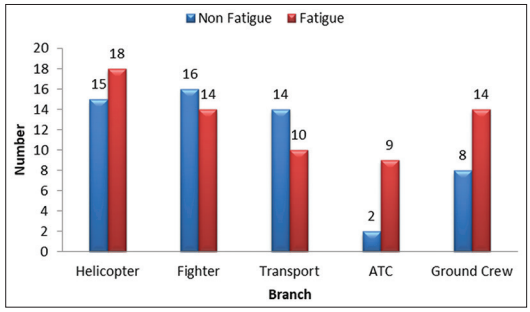

Figure 2: Proportions of crew experiencing fatigue

difference in total fatigue scores among the fighter, transport, and helicopter groups. However, all three of these aircrew groups had significantly lower total fatigue scores compared to the ground crew group. Table 4 demonstrates that relative to the aircrew group, ground support personnel (ground crew and ATC personnel) exhibited a markedly elevated total fatigue score ($P = 0.00001$) across all subscales except vigor. The differences in general ($P = 0.003$), physical ($P = 0.007$), emotional ($P < 0.001$), and mental ($P = 0.02$) were statistically significant. The difference in the vigor dimension was not statistically significant ($P = 0.229$).

Discussion

This study aimed to evaluate the prevalence and characteristics of fatigue among aircrew and ground support personnel within the BAF using the MFSI-SF.[9] Our findings reveal a significant presence of fatigue across both groups, with a particularly noteworthy observation that ground support personnel exhibited a substantially higher

Table 1: Comparison of demographic data between aircrew and ground support personnel (ATC and other ground crew)

Demographic data	Aircrew *n*=87(%)	Ground support personnel *n*=33 (%)	Total	*P*-value
Age in years				
Range	23–54	22–56	-	0.004
Average	33.26	37.39		
SD	±8.28	±7.10		
Gender				
Female	9 (10.34)	4 (12.12)	13	0.76
Male	78 (89.66)	29 (87.88)	107	
Marital status				
Married	51 (58.62)	31 (93.94)	82	<0.001
Unmarried	36 (41.38)	2 (6.06)	38	
Flying experience in hours				
Range	310–5130	--	-	-
Average	1528.65	--		
SD	±1493.40	--		
Length of service in years				0.01
Range	3–25	2-31	-	
Average	12.98	16.09		
SD	±9.95	±9.95		
Branch				-
Helicopter	33 (37.93)	--	33	
Fighter	30 (34.48)	--	30	
Transport	24 (27.59)		24	
Air traffic control personnel	--	11 (33.33)	11	
Other ground support personnel		22 (66.67)	22	

ATC: Air traffic control, SD: Standard deviation

Table 2: Results of one-way ANOVA on comparison of the total fatigue score in aircrew (*n*=87) and ground personnel, including ATC personnel (*n*=33)

Sources of variations	Sum of squares	df	Mean square	F	*P*-value
Between Groups[a]	1102.352	1	1102.352	13.845	0.001
Within Groups	9395.515	118	79.623		
Total	10497.867	119			
Between Groups[b]	155.993	2	77.997	0.965	0.385
Within Groups	6790.007	84	80.833		
Total	6946.000	86			

ANOVA: Analysis of variance, ATC: Air traffic control. [a]: Air crew versus ground personnel, [b]: Helicopter versus Fighter versus Transport

overall level of fatigue than aircrew. This finding challenges the common perception that fatigue is primarily a concern for those directly involved in flight operations and highlights the importance of a broader understanding of fatigue within military aviation.

Table 3: Results of *post hoc* analysis using Tukey's pair-wise comparison

Variables	Helicopter	Fighter	Transport	Ground crew	ATC
Helicopter	--	0.683	0.846	<0.001	0.001
Fighter	0.683	--	1.000	<0.001	<0.001
Transport	0.846	1.000	--	<0.001	<0.001
Ground crew	<0.001	<0.001	<0.001	--	0.987
ATC	0.001	<0.001	<0.001	0.987	--

The observed effect size f is large (0.48). That indicates that the magnitude of the difference between the averages is large

Table 4: Total fatigue score

MFSI (SF)	Aircrew	Ground personnel	*P*-value
	Mean (±SD)	Mean (±SD)	
General scale	8.37 (±3.35)	10.69 (±4.46)	0.003
Physical scale	9.44 (±4.11)	11.78 (±4.17)	0.007
Emotional scale	7.32 (±2.86)	10.09 (±2.05)	0.001
Mental scale	8.48 (±4.45)	10.54 (±4.45)	0.02
Vigor scale	10.11 (±5.24)	11.39 (±4.68)	0.22
Total score	24.00 (±8.98)	30.78 (±8.74)	0.001

The results indicated that nearly half of the aircrew (49.43%) and a considerable majority of ground support personnel (69.69%) met the fatigue threshold of 24 on the MFSI-SF. This overall prevalence underscores fatigue as a significant issue within the BAF, aligning with general concerns about fatigue impacting operational readiness in military settings. While precise comparative data for the BAF is scarce, international studies have estimated that fatigue may be a causative factor in 4–7% of civil aviation accidents.[2] In military scenarios, though data are often sensitive, studies from the USAF and USN have attributed a significant percentage of tactical fighter and naval accidents to fatigue.[3] This suggests the critical need for effective fatigue management strategies, as highlighted in broader reviews of fatigue in aviation.[1,4]

A key finding of this study is the significantly higher total fatigue scores and higher scores across most subscales (general, physical, emotional, and mental) in ground support personnel compared to aircrew. This divergence is particularly striking and warrants further investigation into the specific stressors and working conditions of ground support roles within the BAF. Unlike pilots, who often have structured flight rest regulations and greater awareness of fatigue risks due to their direct impact on flight safety, ground personnel might face less visible but equally demanding pressures, such as long shifts, irregular hours, high workload, or environmental stressors, without the same level of fatigue monitoring or mitigation strategies. Research on fatigue in aircraft line maintenance crews, for instance, has explored psychological and physiological fatigue variations and contributing factors.[6] The subjective and multifaceted nature of fatigue, encompassing both physiological and perceptual aspects, has been extensively studied in various demanding environments, including general human systems and ground transportation.[10,11] The only subscale where a significant difference was not observed was vigor, suggesting that while ground support personnel may experience more fatigue across other dimensions, their self-perceived energy levels might not differ as starkly from aircrew. However, it is important to note that military studies comparing fatigue between pilots and ATCs have shown varied results.[12]

Going deeper into the specific roles, the study revealed that ATC personnel exhibited the highest proportion of fatigue (81.81%) among all surveyed groups, including aircrew. This finding is particularly concerning given the critical role of ATC in ensuring flight safety. The high cognitive demands, pressure of managing air traffic, and

potential for irregular shift patterns inherent in ATC duties are well-known contributors to fatigue, as evidenced by studies on stress reduction in ATCs in other countries.[13] Our results suggest these factors are highly prevalent in the BAF's ATC cohort. Similarly, a considerable percentage (63.63%) of other ground support personnel also experienced fatigue. Among aircrew, fatigue was present across all types, with helicopter crew showing the highest proportion (54.55%), followed by fighter pilots (46.67%) and transport crew (41.67%). The overall fatigue scores, however, were similar among different pilot groups, suggesting that while the proportion of fatigued individuals varied, the intensity of fatigue among those affected was comparable across aircraft types.

Our demographic analysis indicated that younger pilots with shorter service lengths were more prone to fatigue, a finding that merits attention for targeted interventions. This could be attributed to a steeper learning curve, greater exposure to new operational demands, or perhaps less developed coping mechanisms compared to more experienced aircrews. Similar patterns of fatigue concerning age and experience have been noted in other contexts.[7] The statistically significant variations in age, period of service, and marital status between aircrew and ground support personnel further highlight the distinct demographic profiles of these two groups, which may contribute to their differing fatigue levels. For instance, the higher proportion of married individuals in the ground support group could suggest different life demands that contribute to fatigue compared to the predominantly unmarried aircrew. These findings carry significant implications for the BAF. The high prevalence of fatigue, particularly among ground support personnel and ATC, suggests a potential vulnerability in overall operational effectiveness and safety. Studies assessing fatigue among military flying personnel in India[14] underscore the regional relevance of these concerns.

To enhance overall readiness and personnel well-being, BAF should adopt a holistic approach to fatigue management. This involves implementing comprehensive fatigue risk management systems that extend beyond aircrew to rigorously cover all ground support personnel, especially those in critical roles, such as ATC. Such systems should include structured duty-rest cycles, workload assessments, and regular fatigue monitoring.

Furthermore, targeted interventions are essential for high-risk groups. For ground support and ATC, this means investigating specific stressors and developing tailored strategies, such as optimized shift patterns, improved rest facilities, and mental health support. Younger aircrews also need enhanced education on fatigue recognition, stress coping mechanisms, and peer support to help them navigate operational demands effectively.

Crucially, the BAF must promote a strong culture of fatigue awareness across all ranks, destigmatizing fatigue reporting and providing continuous education on its impact on performance and safety. Finally, investing in ongoing research and data collection through regular, anonymous fatigue assessments will allow the BAF to track trends, evaluate intervention effectiveness, and continuously adapt its strategies to maintain a healthy and ready workforce.

Limitations

The study faced several limitations. The small sample size hampered a detailed comparison of total fatigue scores among specific subgroups, such as fighter, transport, helicopter, and ATC personnel. We also found no correlation between the overall fatigue score and the specific symptoms reported by the crew. Furthermore, the MFSI-SF questionnaire, which assesses fatigue over the past week, did not account for the crew's actual occupational workload during that period. Another key limitation is the MFSI-SF is a subjective questionnaire, its results are based entirely on individual self-reports.

Conclusion

Fatigue impacts both aircrew and ground support personnel. The incidence of weariness among

ground support personnel is higher than that of aircrew. The aircrew identified with fatigue is younger and less experienced than their ground support counterparts. A significant proportion of ATC personnel, along with other ground support staff, experience fatigue. Moving forward, the BAF's commitment to implementing comprehensive, inclusive strategies remains paramount to safeguarding operational excellence and ensuring the well-being of every individual dedicated to national defense.

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