Original Research

A Study of Cognitive and Psychomotor Abilities with Advancement of Age in Indian Males Between 50 to 70 Years of Age

Rastogi P*

Abstract

Introduction: The phenomenal growth of the aviation industry has created an increased demand of experienced & qualified pilots and at the same time there is an inevitable increase in number of older pilots. The 'Age 60 Rule' was under controversies since inception as sudden loss of a fit pilot was not acceptable. In this study, cognitive parameters viz. reaction time, vigilance, working memory and spatial orientation abilities, were analyzed to assess the changes with advancement of age.

Methodology: 66 healthy male volunteers of age in between 50 and 70 yr were divided into 4 age groups of 5 year interval (viz. Gp A (50-55), B (55-60), C (60-65) & D (65-70) and each individual was subjected to a battery of 04 computer based tests after familiarization with test protocol in a single sitting. The difference in the test scores were statistically analyzed for significance using ANOVA and post hoc comparison.

Results: Reaction time did not show any significant change across all 4 age groups in simple reaction time, vigilance and working memory tests. In the vigilance and working memory tests a significant decrease in the no. of correct responses was noted in between Gp A & Gp D. In spatial orientation test no significant change was noted in the no.of correct responses and selection time, while a significant increase was noted in the confirmation time of the test in between Gp A & Gp D. No change in performance was noted in between the Gp B & Gp C. The test scores showed no significant change in between successive age groups; however the change was significant in between the Gp A &Gp D.

Discussion: There was no significant change in performance in Indian males between the Gp B & Gp C i.e. across the Age 60. The decline in performance across the Age 65 was found to be significant. Therefore, it can be concluded that up to 65 years of age mental performance does not deteriorate. Inference can be made that the same is true for Indian pilots and that performance decrement is not expected at Age 60 but after Age 65. Therefore, increasing the mandatory age of retirement for commercial pilots to 65 years seems justifiable.

IJASM2015;59(1):15-24

Key words: Age 60 rule, Reaction time, Vigilance, Working memory.

Introduction

The phenomenal growth of the aviation industry in the recent years has created an increased demand of experienced & qualified pilots all over the world and at the same time there is an inevitable increase in number of older pilots.

Till 2005, when the present study was commenced, the International Civil Aviation Organization (ICAO) and the Federal Aviation Administration (FAA) of United States of America had laid down the standards that limit the age of pilot and co-pilot to 60 years (Age 60 Rule) [1, 2]. However Joint Aviation Authorities (JAA) of Europe permitted the age limit of 65 years in multi-pilot crew operations [3]. During the course of this study, ICAO and DGCA increased the upper age limit of pilot retirement to 65 years [4].

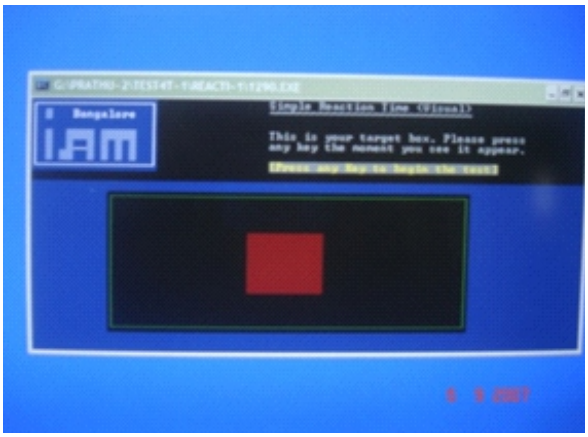
The rules of mandatory retirement at 60 were established with concern that aging pilots might present safety hazard in air operations. During the last few decades, various studies have been carried

**Assistant professor, Department of Acceleration Physiology and Spatial Orientation, IAM IAF and Classified Specialist (Aviation Medicine)*

out to assess the relationship between age, experience, pilot performance and potential risks of incapacitation related to age. Results have differed significantly from study to study thus making it difficult to understand the relationship between age, pilot performance and safety. Thus, there was a need to study the changes in cognitive and psychomotor functions with increase in age. Therefore, the present study was undertaken to identify age related changes in reaction time, vigilance, working memory and spatial orientation abilities of Indian males above 50 years of age and to ascertain a cut off age, if possible, after which there occurs rapid decline in cognitive function.

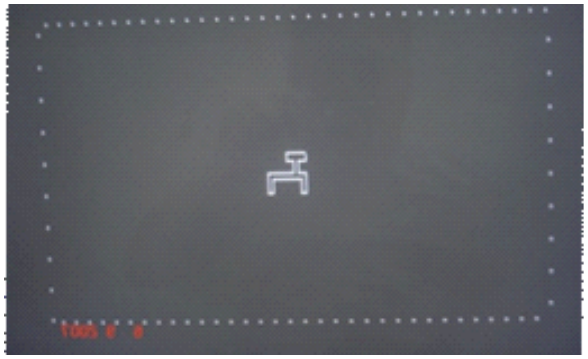
Methodology

66 healthy male volunteers of age in between 50 and 70 years were divided into four age groups of 5 year interval and each individual was subjected to a battery of computer based tests after familiarization with test protocol and methodology. The battery comprised of 4 tests which were administered to an individual in a single sitting. The test scores were recorded after two sets of trials in which the subject became familiar and comfortable with the test protocol. The test battery comprised of:



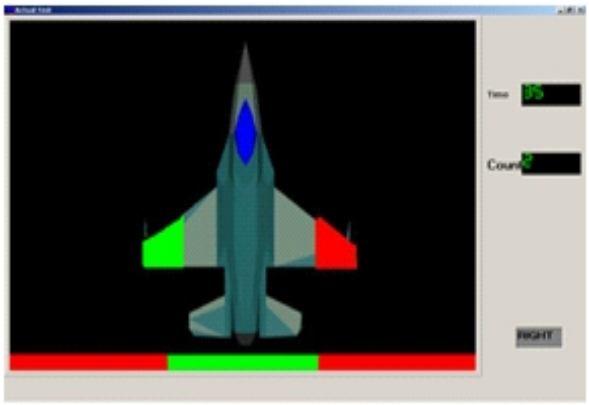
(a) **Simple Reaction Time Test:** The subjects were asked to concentrate on the blank computer screen and were told to respond by pressing the 'space bar' on the key board as soon as they saw a red colored solid block in the centre of the computer screen. After the stipulated time period test ended automatically and the result were saved to the hard disc in the form of reaction time for each response and the mean of all the response times, which was taken as simple reaction time of the subject for the particular trial.

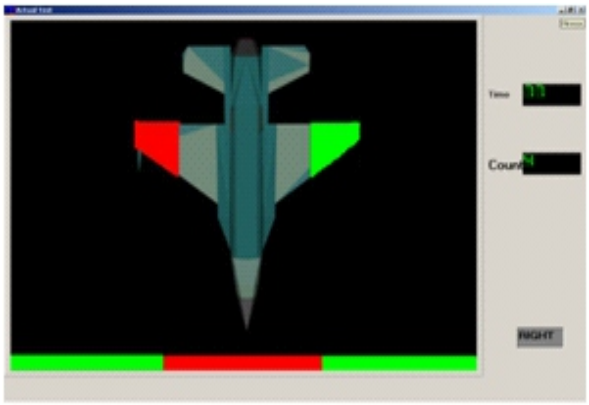
(b) **Vigilance Test:** The subjects were shown different geometrical figures, which flashed on the computer screen, one after another, after a very short and fixed interval. The subjects were asked to detect immediate repetition of the same figure to which they responded by a pressing the 'space bar'. The subjects were exposed to the test for a total of 100 figures in each set. The test results were automatically calculated and saved on the hard disc in form of total number of stimuli, number of repeats, number of correct responses, number of incorrect responses, number of missed responses and the response time.



(c) **Working Memory Test:** The subjects were asked to identify a target figure in an array of similar four figures which followed the target figure on the computer screen. The array comprised of four similar figures arranged horizontally in a row. The target figure could be at any location of the array or could be absent also. The subjects were asked to identify the target stimulus in the array and to respond by different key presses if the target appears on the right half (location 1and 2) or on the left half (location 3and 4) of the array or does not appear in the array at all. The 'space bar' was used to give 'left' response, the 'insert' key for 'right' response and the 'absent' response was given by pressing 'enter' key on the key board. All occurrences had equal probability. The subject was exposed to the test for a period of two minutes in each set, after which test was terminated by pressing 'S' key.

The test results were automatically calculated and displayed on the screen in the form of total number of stimuli, number of correct responses (on the left, right and absent),number of incorrect responses (on left, right and absent) and the average response time for left, right and absent responses.





(d) **Spatial Orientation Test:** This test measures the ability of an individual to orient self or resolve the orientation of objects or images in space. The subjects were shown pictures of an aircraft on the computer screen. Each picture was a two dimensional sketch of an aircraft viewed either from the top or from the bottom, in either nose up or nose down attitude. The subject had to identify the wing tip with target colour as Right' (starboard) or 'Left' (port) side of the aircraft by pressing 'Right' and 'Left' arrow keys for the corresponding responses

and to confirm their response by pressing 'Enter' key. There were total of 16 pictures shown in each set and the pictures were randomly displayed in each set with equal probability for all possible combinations. The subject had the choice to change the response before pressing 'Enter'. On completion of the test results are automatically computed and saved to hard disk in the form of total number of correct responses, incorrect responses, extra key presses, average and SD of selection time, confirmation time and total time taken The computer tests used in this study and their test settings have been used earlier in the studies carried out at IAM IAF, Bangalore [6, 7, 8, 9, 10, 11].

Statistical Analysis

The data was collated and analyzed. The data was checked for normality using Shapiro Wilk's test. The deviation from normality was small.The difference in the test scores were statistically analyzed for significance using ANOVA and post hoc comparison by the Tukey's HSD test. For statistical significance, the "p value" was set at 5% level of confidence.

Results

The mean and standard deviation for the four age groups for the scores obtained in the four computer-based mental function tests have been placed below as Tables 1 to 8.

Table-1:
Performance in Simple Reaction Time Test

Groups	Reaction Time (msec) [Mean ± SD]
Group A	0.48 ± 0.08
Group B	0.60 ± 0.19
Group C	0.52 ± 0.14
Group D	0.54 ± 0.15

Results of ANOVA , F = 2.1991 ; p = 0.0970

Table-2:
Performance in Vigilance Test, Correct Response

Groups	Correct Responses (No.)[Mean ± SD]
Group A	5.24 ± 1.34
Group B	4.46 ± 1.98
Group C	5.00 ± 1.52
Group D	3.56 ± 1.54

Results of ANOVA, F = 4.1251; **p = 0.0098**
Post hoc comparison between gp A and D, **p= 0.0111**

Table-3:
Performance in Vigilance Test, Response Time

Groups	Response time (sec)[Mean ± SD]
Group A	0.28 ± 0.05
Group B	0.32 ± 0.06
Group C	0.28 ± 0.05
Group D	0.28 ± 0.07

Results of ANOVA, F = 0.9708 ; p = 0.4122

Table-4:
Performance in Working Memory Test, Correct Responses

Groups	Correct Response (No.) [Mean ± SD]
Group A	27.67 ± 4.58
Group B	25.23 ± 3.77
Group C	25.07 ± 5.19
Group D	21.67 ± 6.94

Results of ANOVA, F = 4.1158; **p = 0.0099**
Post hoc comparison between gp A and D, **p = 0.0068**

Table-5:
Performance in Working Memory Test, Response Time

Groups	Response time (sec) [Mean ± SD]
Group A	1.21 ± 0.28
Group B	1.22 ± 0.21
Group C	1.13 ± 0.23
Group D	1.32 ± 0.56

Results of ANOVA, F = 0.7624 ; p = 0.5194

Table-6:
Performance in Spatial Orientation Test, Correct Responses

Groups	Correct Response (No.) [Mean ± SD]
Group A	11.62 ± 3.14
Group B	11.38 ± 2.76
Group C	12.64 ± 1.82
Group D	11.89 ± 1.94

Results of ANOVA, F = 0.6671 ; p = 0.5754

Table-7:
Performance in Spatial Orientation Test, Selection Time

Groups	Selection time (sec) [Mean ± SD]
Group A	4.93 ± 1.39
Group B	4.64 ± 1.72
Group C	4.94 ± 1.40
Group D	5.84± 1.48

Results of ANOVA, F = 2.038 ; p = 0.1176

Table-8:
Performance in Spatial Orientation Test, Confirmation Time

Groups	Confirmation time (sec) [Mean ± SD]
Group A	0.64 ± 0.22
Group B	0.84 ± 0.28
Group C	0.79 ± 0.33
Group D	0.94 ± 0.39

Results of ANOVA, F = 3.221; **p = 0.0286**
Post hoc comparison between gp A and D, **p = 0.0233**

Discussion

In this study an attempt was made to find out if performance decreased dramatically at Age 60 or not. Performance was studied as essentially a function of the basic parameters of mental function such as simple reaction time, vigilance, working memory and spatial orientation abilities. It was expected that the changes in these attributes would be occurring gradually with age and no sudden deterioration in these functions was expected to occur dramatically at any chronological point.

In Simple Reaction Time Test there was no statistically significant difference (F =2.1991; p = 0.0970) between the four age groups. Thus it can be inferred that simple reaction time, which measures a person's quickness to respond to a given situation, did not show a decline with increase in age up to 70 years of age. This finding of a fairly constant reaction time with age was consistent with the observations of Kosinski RJ,Sherwood DE & Selder DJ, Spirduso & Clifford, and others [12, 13, 14, 15, 16].

In Vigilance Test the number of correct responses decreased with the increase in the age. There was a statistically significant difference noted in between the groups (F = 4.1251; p= 0.0098). The difference between the performance of group A (50 to 55 years) and group D (65 to 70 years) was statistically significant (p = 0.0111). The difference between the other groups was not statistically significant. This shows that there was a decrease in vigilance after 65 years of age. There was no statistically significant change (F = 0.9708;p = 0.4122) noted in the response time of the Vigilance Test across the four age groups. Vigilance or sustained attention is the ability to maintain the attention for a prolonged period of time while doing some monotonous kind of job, e.g., picking up only the relevant stimulus from an

array of similar stimuli. Vigilance is of great importance in flying, especially in long duration flights, where pilot has to maintain a high level of alertness all the time scanning a number of displays and the view outside. Thus decrease in vigilance is a potential risk to flight safety.

In Working Memory Test, the number of correct responses had decreased with increase in the age of the subjects ($F = 4.1158$; $p = 0.0099$). The difference between the age group A (50 to 55 years) and group D (65 to 70 years) was found to be statistically significant ($p = 0.0068$). Between other age groups, the change was not statistically significant. It can be inferred that there was no significant change in working memory from 50 to 65 years and significant change became evident only after 65 years of age. In the response time of the Working Memory Test no statistically significant change ($F = 0.7624$; $p = 0.5194$) noted across the four age groups.

Working memory is a form of short term memory and is important for information processing. This is a continuous process in piloting and good working memory is a crucial attribute for understanding and analyzing the numerous instruments and displays. The number of correct responses measured the ability of an individual to correctly remember the stimulus and to recall it promptly for identifying the stimulus in the array. Decline in working memory is explained by the slow encoding of the information, due to age related decline in sensory inputs like vision and hearing, and decreased ability to form new neurological connections in the brain with increase in age. The finding of no substantial decline in working memory till 65 years of age is in conformity with findings of Reed D et al, and others [17, 18, 19].

In the Spatial Orientation Test, there was no statistically significant change in the number of correct responses ($F = 0.6671$; $p = 0.5754$) and selection time ($F = 2.038$; $p = 0.1176$) across the four age groups, inferring that the spatial orientation abilities were not affected by increase in age of the subjects. In the confirmation time of the Spatial Orientation Test an increase ($F = 3.221$; $p = 0.0286$) was found with increase in the age across the four age groups. In between the age group A (50 to 55 years) and group D (65 to 70 years) there was statistically significant difference ($p = 0.0233$) in the performance, while no such change was found between the other age groups.

Spatial orientation is the ability to mentally represent the physical environment around us. There was no difference in the spatial orientation ability in the four age groups. Also, in the selection time response in this test there was no difference amongst the four age groups. However, in the confirmation time, a significant difference was noted in the age group of 65 to 70 years. This delay in confirming the response could be due to slowing in sequential responses because of poor neuromuscular coordination in the older age group.

The detailed analysis of the study reveals that there was statistically significant difference in performance of the age group A (50 to 55 years) and group D (65 to 70 years). The differences between the successive age groups were not found to be statistically significant. The contention that mental functions do not rapidly deteriorate at age of 60 has been supported by the findings of a number of workers. Schroeder DJ, Mohler SR (1981)Morrow DG (2000), Castelo BA (1985) Tsang, P.S (1999) and Sekuler R (1982) have reported that age related decline in cognitive function if any was very gradual and well compensated by expertise on the job [15, 16, 20, 21, 22,23, 24, 25, 26, 27]. Wilkening R(2002), Reed D et al , Isbell L, and others have opined that decline in mental function becomes evident only in late 60s or after the age of 70 years [15, 17, 19, 28, 29, 30, 31]. A decline in the mental function after the age of 65 years have also been documented in the works of Reed D et al, Isbell L and other workers [15, 17, 28, 29, 30, 31, 32]. These works support the findings in this study, that the

significant change in mental performance occurred after 65 years of age.

The main hindrance in increasing the age of commercial pilots has been the fear of increased risk to flight safety and increased incidence of pilot error, which would endanger many lives. That, the limiting age can be increased is supported by a large number of studies. Wilkening R (2002), Schroeder DJ, Mohler SR, Rebok et al (1991),Baker S et al (2001) and Hilton study of FAA have, all reported a similar or lesser rate of accidents involving pilots above 60 years of age in general aviation [15, 20, 28, 33, 34, 35,36]. Miurya Y et al (2002) in an analysis of accident data over a 10 year period had found that commercial pilots of age group 60 to 63 years were not involved in any of the accidents [37].

However, it has also been reported that there is an increase in accident rate after 65 years of age among the general aviation pilots [8].A physically and mentally fit pilot capable of performing his flight related duties and undergoing regular screening for health and flight performance by medicals and simulator testing is not at increased risk for any aviation mishap just by increasing the age.

The statistically significant decline in the performance noticed in the age group of 65 to70 years indicates that there is an increase in the risk and pilots should not be allowed to fly commercial planes past the age of 65 years. To understand the dynamics of performance decrement beyond the age of 65 years more studies are required to be undertaken.

An increase in age limit for pilots will raise two important issues; one decrease in physical fitness due to infirmity, disease or disability and the other due to decrease in mental performance. With modern screening facilities and regular medical checks the population of working pilots is certified as physically healthy with no undue risk of disability or sudden incapacitation. The issue of mental fitness remains a big question to be answered and this issue is addressed by the current study on mental performance.

The present study has shown that mental ability remain unchanged across the age 60 i.e. no change in performance was noted in between the age group B (55 to 60 years) and group C (60 to 65 years), and the decrement in mental function is evident only after the age of 65 years in this study. The results have been obtained from the general population and the inferences have been drawn for the pilot population. To make conclusive statement on the issue of retirement age of commercial pilots, studies specific to pilot tasks and involving pilot subjects may be more fruitful.

Conclusion

Based on above finding following inferences can be drawn:-

(a) Successive age groups did not show significant difference in mental performance.

(b) There was no significant difference in mental performance across the Age 60. i.e., between group B (55 to 60 years) and group C (60 to 65 years).

(c) Decline in mental performance became significant beyond the Age 65.

(d) Between the extremes of age groups i.e. between group A (50 to 55 years) and group D (65 to 70 years) there were significant differences in three attributes of mental performance (vigilance, working memory and spatial orientation) studied.

In the context of retirement age of Indian commercial pilots, the results of this study seem to support the increase in age of retirement from 60 to 65 years, as change in mental performance was not found across Age 60 but the change became evident after Age 65.

References

1. International Civil Aviation Organization. Age limit for flight crew and other Annex 1 changes to SARPs. Paragraph 2.1.10.1 & 2.1.10.2. Available at: http://www.intlpilot.com/index2.php/option=com_content &do_pdf=1&id=27. Accessed September,09, 2007.

2. Federal Aviation Regulations 14 CFR. Chapter 1, part 121.383 Airman: Limitations on use of services. Paragraph (c). Available at: http://www.access.gpo.gov/nara/cfr/waisidx_98/14cfr121_98.html. Accessed September,09, 2007.

3. Joint Aviation Regulations. Flight Crew Licensing (medical). JAR – FCL 3.060, paragraphs a(1), a(2) & b. Available at: http://www/jaa.nl/publications/jars/606984.pdf. Accessed September,09, 2007.

4. International Civil Aviation Organization. Air Navigation Bureau (ANB). Amendment 167 to Annex 1. paragraph 2.1.10.1 & 2.1.10.2. Available at: http://www.icao.int/cgi/goto_m_anb.pl/icao/en/trivia/peltrgFAQ.htm. Accessed September,09, 2007.

5. Wadhawan ML. Aging and flying fitness. Aviation Medicine.1978;22(1):31-3.

6. Dahiya M. Gender based differences in auditory tone discrimination, working memory and vigilance task in cadet of air force academy. Field project report. IAM IAF, Bangalore;2005.

7. Sant JS, Verghese CA, Chaterjee PC . Performance, Physical capacity and psychological capability of the aircrew with a view to determine contributory causes for decrements with advancing age. Departmental project report. no. 905/77;IAM IAF, Bangalore;1977.

8. Khurana A. Temporal variations in vigilance, working memory and arithmetic abilities during eight hours of acute sleep deprivation. MD Dissertation. Rajiv Gandhi University of Health Sciences, Bangalore;2006.

9. Patil GR. Visuo-spatial working memory under conditions of acute monocularity. MD Dissertation. Rajiv Gandhi University of Health Sciences, Bangalore;2006.

10. Tripathi KK, Apte CV, Mukundan CV. Temporal adjustments in working memory and vigilance function during six days of acclimatization at 10,500 feet altitude. Ind J Aerospace Med 2005;49(1):20-8.

11. Ramachandran N, Prabha K, Kumar V, Banerjee KR. Spatial Orientation Test. It's use in aviation. Aviation Medicine.1980;24(1):19.

12. How long does it take to stop? Methodological analysis of driver perception-brake times.Transportation Human Factors. 2000;2:195-216. Available at: http://www.visualexpert.com/Resources/green_transportation_hf.pdf. Accessed February,01, 2006.

13. Kosinski RJ. A literature review on reaction time. Available at: http://biae.clemson.edu/bpc/bp/Lab/110/reaction.htm. Accessed February,01, 2006.

14. Sherwood DE, Selder DJ. Cardiorespiratory health, reaction time and aging. Medicine and science in sports.1979;11(2):186-9. Abstract Available at: http://www.ncbi.nlm.nih.gov/sites/entrez?cmd=Retrieve&db=PubMed&list_uids= 491879 & dopt=Abstract. Accessed June,19, 2007.

15. Mohler SR. Reasons for eliminating the "AGE 60 "Regulation for airline pilots. Aviat Space Environ Med 1981;52:445-54.

16. Rebok GW, Li G, Baker SP, Grabowski JG, Willoughby S. Self rated changes in cognition and piloting skill: a comparison of younger and older airline pilots. Aviat Space Environ Med 2002;73:466-71.

17. Reed D. et al. Stress, health and aging. Module 3: Normal change of aging. Available at: http://www.ageworks.com/course_demo/513/module3/module3.htm. Accessed September,05, 2005.

18. Ageing: science, medicine and society. Available at: http://www.absw.org.uk/Briefings/Ageing.htm. Accessed July,22, 2005.

19. Cavanaugh JC. Memory and aging. National forum. 1998;Spring. Available at: http://findarticles.com/p/articles/mi_qa3651/is_19 9804/ai_n8790237. Accessed August,11, 2007.

20. Schroeder DJ, Harris HC, Broach D. Pilot age and performance: An annotated bibliography (1990-1999). Civil aeromedical institute. Federal Aviation Administration. Available at: http ://www.faa.gov/library/reports/medical/age60/med ia/age60_1.pdf. Accessed August,22, 2007.

21. Morrow DG, Menard WE, Ridolfo HE, Elizabeth AL, Teller T, Bryant D. The International Journal of Aviation Psychology.2003;13(4):345-71.

22. Castelo BA, Cabral SA A, Coelho BJ. Comparative study of physical and mental incapacities among Portuguese airline pilots under and over age 60. Aviat Space Environ Med 1985;56:752-7.

23. Kay EJ. Effects of aging on aviation related cognitive functioning in commercial airline pilots. Paper presented at the 63rd Annual Scientific Meeting of the Aerospace Medical Association, Miami Beach, FL. Abstract in Aviat Space Environ Med 2001;72:241.

24. Tsang, P.S. (1999). Retention and transfer to time-sharing skill as a function of age and flight experience. Paper presented at the 10th International Symposium on Aviation Psychology, Columbus, OH, May. Abstract in Schroeder DJ, Harris HC, Broach D. Pilot age and performance: An annotated bibliography (1990- 1999). Civil Aeromedical Institute. Federal Aviation Administration. Available at. http://: www.faa.gov/library/reports/medical/age60/media /age60_1.pdf. Accessed August,22, 2007.

25. Tsang, P.S. (1992). A reappraisal of aging and pilot performance. International Journal of Aviation Psychology.1992;2:193-212.

26. Tsang, P.S., & Voss, D.T. (1996). Boundaries of cognitive performance as a function of age and flight experience. International Journal of Aviation Psychology.1996;6:359-77.

27. Sekuler R, Kline D, Key. Aging and visual function of military pilots: a review. Aviat Space Environ Med 1982;53:747-58.

28. Wilkening R. Review article: The age 60 rule: age discrimination in commercial aviation. Aviat Space Environ Med 2002;73:194-202.

29. Isbell L. Physical changes in aging. Available at:http://muextension.missouri.edu/explore/hesgui de/humanrel/gh6729.htm. Accessed September,05, 2005.

30. Aerospace Medical Association, Aviation Safety Committee, Civil Aviation Safety Subcommittee. The Age 60 Rule. Aviat Space Environ Med 2004;75:708- 15.

31. The latest research on how age-related decline is studied. The American Federation for aging research. Available at: www.healthandage.com /html/min/afar/content/other6_5.htm. Accessed September,05, 2005.

32. Solutions for Aging. Available at: http://www.soulwork.net/sw_articles_eng/aging.htm. Accessed July,22, 2005.

33. Wilkening R. The Age 60 rule: age discrimination in commercial aviation. Available at: http://www.pilotfriend.com/aeromedicine/2.htm. Accessed August, 30, 2005.

34. Eyraud MY, Borowsky MS. Age and pilot

performance. Aviat Space Environ Med 1985;56:553-8.

35. Rebok, G.W., Grabowski, J.G., Baker, S.P., Lamb, M.W., Willoughby, S., & Li, G.(1999). Pilot age and performance as factors in aviation crashes. Poster presented at the Annual Meeting of the American Psychological Association, Boston, MA. Abstract in Schroeder DJ, Harris HC, Broach D. Pilot age and performance: an annotated bibliography (1990-1999). Civil Aeromedical Institute. Federal Aviation Administration. Available at: http://www.faa.gov/library/reports/medical/age60/media/age60_1.pdf. Accessed August,22, 2007.

36. Baker S, Lamb MW, Grabowski JG, Rebok G, Li G. Characteristics of general aviation crashes involving mature male and female pilots. Aviat Space Environ Med 2001;72:447-52.

37. Miura Y, Shoji M, Fukumoto M, Yasue K, Tsukui I, Hosoya T. A 10 year retrospective review of airline transport pilots aged 60 to 63 in Japan. Aviat Space Environ Med 2002;73:485-7

Disclaimer

The opinions expressed in this article are those of the author and do not reflect the official views of Indian Air Force or the Indian Society of Aerospace Medicine