Hypertension and Obesity Among Civil Aviation Pilots

Keshavamurthy Ganapathy Bhat; Niket Verma; Pankaj Pant; Manvinder Pal Singh Marwaha

BACKGROUND: Raised blood pressure (BP) is a risk factor for cardiovascular disease, which is a common cause of sudden in-flight incapacitation among pilots. Prevalence of hypertension (HT) among pilots as per new criteria is largely unknown. This study aims to understand the prevalence of hypertension and obesity in civil aviation pilots and their correlation.

METHODS: Enrolled were 1185 civilian pilots reporting for medical evaluation to a regulatory medical establishment in India. Their height, weight, and blood pressure (BP) were measured. Pilots were categorized as hypertensive or normotensive as per JNC VIII criteria and hypertensive, having elevated BP, or normotensive as per new ACC/AHA criteria of 2017. Data were analyzed for prevalence of obesity and overweight as per both WHO and Asia Pacific criteria. Results were analyzed using SPSS version 17.

RESULTS: Prevalence of hypertension was 4.1%. Maximum hypertensives were in the 26–35 yr age group. Under the new ACC/AHA guidelines, prevalence of HT was 18.7%. Prevalences of overweight and obesity as per WHO criteria were 39% and 7.3% and as per Asia Pacific guidelines were 23.3% and 46.3%, respectively. As BMI increased above 23, risk of developing hypertension or white coat hypertension as per JNC VIII criteria increased by 6.86 times (OR 6.86, 95% CI 0.9–52.58).

CONCLUSIONS: Prevalence of HT rose from 4.1% to an alarmingly high 18.7% when new criteria were applied. Prevalence of obesity was 7.3% but increased to 46.3% when Asia Pacific guidelines were applied. Risk of hypertension increased as BMI increased above 23 $kg \cdot m^{-2}$.

KEYWORDS: pilots, hypertension, obesity, Body Mass Index, aviation.

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Hypertension or high blood pressure, a condition in which the blood pressure in the arteries is persistently elevated, is more prevalent across the world than previously thought. According to WHO, in 2015, the prevalence of raised blood pressure in women and men ages 18 and over was about 20% and 24%, respectively.[16] Aircrew are generally healthier than the general population due to their selection process, health awareness, and regular annual medical examination. In a Chinese study, the prevalence of hypertension (HT) in civilian pilots was found to be 4.96%[6] and a significant number of hypertensive pilots were overweight or obese. Raised blood pressure is a major risk factor for coronary heart disease and ischemic and hemorrhagic stroke, which are, in turn, leading causes of morbidity and mortality.[19] Cardiovascular disease, particularly myocardial infarction, is the commonest cause of sudden in-flight incapacitation.[8,10] Recent studies[11,20] have indicated that young adults (<40 yr) with elevated blood pressure, as defined by the 2017 ACC/AHA hypertension guidelines,[15] face significantly increased risk for cardiovascular events in middle age.

Obesity has reached epidemic proportions worldwide and is becoming increasingly common among pilots too. A Brazilian study showed that 53.7% of their pilots were overweight and 14.6% were obese.[3] Obesity, which is an excess fat storage associated with clearly elevated health risks, is difficult to measure. Hence it is indirectly measured based upon body mass index (BMI), waist circumference, or waist-hip ratio. Previous studies have noted a positive correlation between increasing BMI

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values and increased prevalence as well as increased morbidity and mortality from hypertension, cardiovascular diseases, diabetes mellitus, and other chronic diseases.[1]

Pilots undergo regular medical evaluation and fitness assessment to ensure flight safety.[9] In India, hypertension is one of the grounds for a civil pilot to be declared temporarily unfit for flying. A pilot faces loss of medical fitness certification for 4-8 wk when diagnosed with hypertension and can resume flying only after control of blood pressure.[4] Presently JNC VIII criteria for hypertension are used. Although prevalence of hypertension has been studied extensively in the general population, very few such studies have been conducted on civilian aviation pilots in India. The prevalence of hypertension in pilots, as per the new ACC/AHA 2017 criteria, is largely unknown.

METHODS

Subjects

Consecutive civilian pilots reporting for medical examination to a medical evaluation center in New Delhi, India, were screened for enrollment in the study. The period of the study was from October 2017 to February 2018. This was a cross-sectional observational study. Pilots ages ≥18 yr and who gave informed consent were included in the study. Those who failed to give consent were planned for exclusion from the study. However, there were no pilots who declined to be enrolled since it was an observational study and privacy was protected.

Considering a confidence interval (CI) of 95%, prevalence of hypertension 5%, margin of error 5%, and the target population of 10,000, the sample size required was 370. However, a total of 1185 civil aviation pilots were studied. Henceforth, in this article, the civil aviation pilots shall be referred to as 'pilots'.

All the subjects were voluntary participants in the medical evaluation. Ethical clearance was obtained from the institutional ethical committee. Official permission was obtained from the Directorate General of Civil Aviation (DGCA) for using the data obtained in the medical evaluation for this study.

Procedure

Blood pressure readings were taken as per standard guidelines.[13] Casual sitting blood pressure in the right arm (using appropriate adult cuff size) was measured after 5 min of rest. A second reading was taken after a further 5-min gap. The average of the two readings was taken as casual blood pressure (BP). If casual BP was ≥140/90 mmHg, 24-h ambulatory blood pressure monitoring (ABPM) was recorded as per DGCA guidelines.[4] After ABPM, pilots were further categorized as normal or hypertensive as per standard criteria for ABPM.[14] A daytime (awake) average of ≥135/85, nighttime (sleep) average of ≥120/70 or 24-h average of ≥130/80 is categorized as hypertension.[14]

The pilots whose blood pressure values were ≥140/90 mmHg initially but were normal after ABPM were classified as having 'white coat hypertension' (WCH). Pilots were also analyzed as per the new ACC/AHA criteria of 2017 for hypertension[15] (**Table I**).

As these criteria have been published only recently, there are no standard guidelines by DGCA on the further disposal of pilots categorized as having elevated BP or hypertension as per these criteria. Hence, no further action was taken and the pilots were simply classified into three categories under this classification without any implication for treatment or disposal.

Height and weight of all participants were recorded and BMI was calculated using the formula: BMI = weight in kg/(height in meters)^2 and expressed as kg/m^2. For BMI classification, the standard World Health Organization (WHO) criteria[17] were used as per the DGCA guidelines. A BMI of 18.5 to 24.9 is considered normal, 25 to 29.9 overweight, and 30 or more is considered obesity; a BMI of <18.5 is underweight.[17]

Pilots were categorized as underweight, normal, overweight, or obese for further evaluation and necessary advice. Their BMI was also analyzed as per Asia-Pacific criteria.[18] A BMI of 18.5 to 22.9 is considered normal, 23 to 24.9 overweight, and 25 and above is considered obesity as per Asia Pacific Criteria.[18] This categorization was only for the purpose of this study without having any implications for further disposal. Blood pressure and BMI values were correlated separately using JNC VIII criteria and new ACC/AHA criteria for HT, and WHO and Asia Pacific criteria for overweight and obesity.

Statistical Analysis

Data were analyzed using SPSS Version 17. Discrete values were expressed as percentage and continuous variables as mean ± SD. Student *t*-test was used to assess the significance of difference in mean values and the Chi-squared test for evaluation of frequencies of variables. A *P*-value of <0.05 was considered significant and <0.01 highly significant. Odds ratios and 95% confidence intervals were calculated wherever relevant.

RESULTS

A total of 1185 pilots were studied. The mean age of the pilots was 34.8 ± 13.7 yr (range 18 to 65). There were 1071 men and 114 women. The highest number of hypertensives (as per JNC VIII) were noted in the 26 to 35 yr age group. As per JNC VIII criteria, 1056 pilots (89.1%) were normotensives on their first visit, while the BP measurement in the remaining 129 (10.9%) was ≥140/90 mmHg. These 129 pilots were subjected to 24-h

Table I. New ACC/AHA Hypertension Guidelines vs. JNC 8 Guidelines: Make 130 the New 140.

SYSTOLIC, DIASTOLIC BLOOD PRESSURE (mmHg)	JNC 8	2017 ACC/AHA
<120 and <80	Normal BP	Normal BP
120–129 and <80	Prehypertension	Elevated BP
130–139 or 80–89	Prehypertension	Stage 1 hypertension
140–159 or 90–99	Stage 1 hypertension	Stage 2 hypertension
≥160 or ≥100	Stage 2 hypertension	Stage 2 hypertension

ABPM. Out of the 129, normal 24-h ABPM was observed in 81 (6.8%) pilots, while the remaining 48 (4.1%) were categorized as hypertensives as per standard criteria. Therefore, after ABPM, 48 pilots (4.1%) had hypertension. The remaining 81 pilots (6. 8%) with raised BP on the first visit but normal BP recordings in the 24-h ABPM were classified as having white coat hypertension (**Fig. 1**)

The average of the 24-h ABPM was 146.5/85.6 mmHg. The average casual BP of those who underwent ABPM was 153.9/90.7 mmHg. The average of the 24-h ABPM was 7.4/5.1 mmHg less than the casual BP average.

On using the new ACC/AHA 2017 criteria for BP classification, 222 pilots (18.73%) were diagnosed with hypertension on the first visit (BP ≥130/80) and 801 pilots (67.6%) were diagnosed as having 'elevated' BP (≥120/70). Only 162 pilots (13.67%) were classified as normotensive (<120/70) on the first visit (Fig. 1). On calculating 10-yr atherosclerotic cardiovascular disease risk (10-yr ASCVD risk), an additional 6.2% (over and above hypertensives as per JNC VIII) of pilots were qualified to be on antihypertensive medication due to their risk being >10%. As these guidelines are not used for further investigation and/or management at present, 24-h ABPM was not performed on these pilots with elevated BP or hypertension as per these novel criteria.

When BMI was analyzed as per the WHO criteria, 462 pilots (39%) were diagnosed as overweight and 87 (7.3%) were diagnosed as obese. The data were then further analyzed for correlation between BMI (WHO Criteria) and HT (JNC VIII). Of the 129 pilots with BP ≥140/90 mmHg on the first visit, 18 were obese, 60 were overweight, and 51 had a normal BMI. Out of the 48 pilots classified as hypertensives after 24-h ABPM, 6 were obese, 27 were overweight, and 15 had a normal BMI.

When Asia-Pacific guidelines were used for classifying BMI, the number of obese pilots increased to 549 (46.3%) and the number of overweight pilots decreased to 276 (23.3%). Out of the 129 pilots with BP ≥140/90 on the first visit, 78 were obese, 30 were overweight, and 21 had a normal BMI. Out of the 48 pilots classified as hypertensive after 24-h ABPM, 33 were obese, 12 were overweight, and only 3 had a normal BMI. As the BMI increased above 22.9, there was a linear increase in both systolic and diastolic BP readings, suggesting better correlation with Asia-Pacific criteria (**Fig. 2** and **Fig. 3**). However, the R-squared (coefficient of determination) is quite modest (around 0.05).

If a pilot was overweight or obese as per WHO Criteria, then he/she was 1.9 times more likely to have BP ≥140/90 (i.e., hypertension) on the first visit (OR 1.9, 95% CI 0.99–3.6). If a pilot was overweight or obese as per Asia-Pacific criteria, then he/she was 2.43 times more likely to have BP ≥140/90 on the first visit as compared to a pilot who had normal BMI or was underweight (OR 2.432; 95% CI 1.050–5.632). When using the Asia-Pacific criteria, the odds of being hypertensive on the first visit are significantly higher among overweight and obese pilots as compared to pilots with normal BMI or underweight pilots ($P < 0.05$ implying statistically significant correlation).

After ABPM, 48 pilots were hypertensives and 81 were noted to have WCH. On calculating the odds ratio comparing the 48 pilots categorized as hypertensive after the ABPM with the 1137 who were classified as normotensive (1056 classified as normotensive on the first visit and 81 reclassified as normotensive after 24-h ABPM), we found that a pilot was 2.65 times more likely to be hypertensive (OR 2.65, 95% CI 0.9–7.77) if he/she was overweight or obese as compared to a pilot who had normal/underweight BMI when we used the WHO Criteria for BMI. On using the Asia-Pacific criteria, we noted that a pilot was 6.86 times more likely (OR 6.86, 95% CI 0.9–52.58) to be hypertensive if he/she was overweight or obese as compared to a pilot who had normal BMI or was underweight.

In both cases (WHO and Asia-Pacific), the odds of being diagnosed with hypertension are significantly higher among overweight and obese pilots as compared to pilots with normal BMI or underweight pilots (*P*-value <0.01 in both cases, i.e., highly significant). In other words, the relative risk of hypertension is significantly higher among pilots with higher than normal BMI, irrespective of whether the BMI is classified by WHO criteria or by Asia-Pacific criteria. The prevalence of hypertension in our study was 4.1% (as per the JNC VIII criteria). The prevalence increased to 18.73% when the new ACC/AHA criteria were used.

The prevalence of overweight and obesity was 39% and 7.3%, respectively, as per WHO criteria. However, the same changed to 23.3% and 43.3%, respectively,

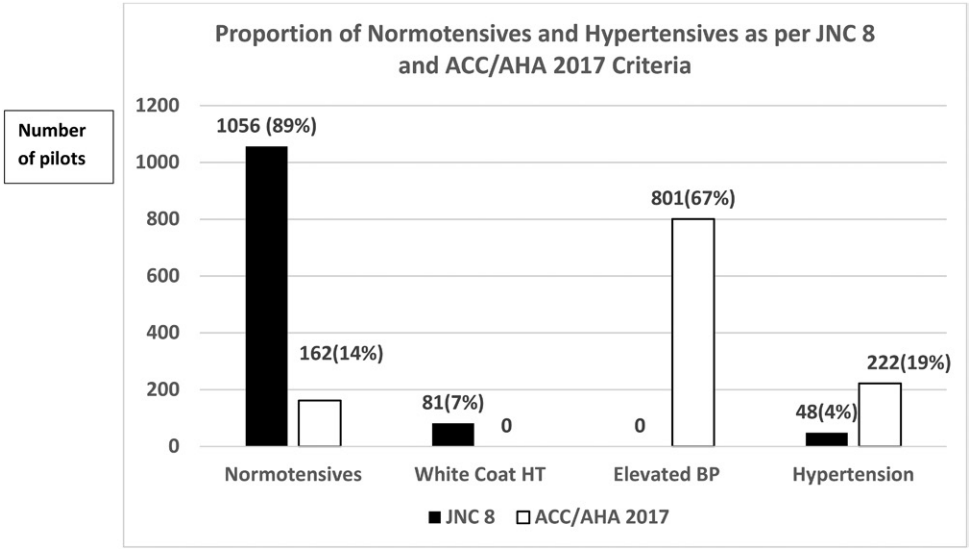

Fig. 1. Prevalence of normotension, white coat hypertension (WCH), elevated BP, and hypertension as per JNC VIII criteria and as per new ACC/AHA criteria.

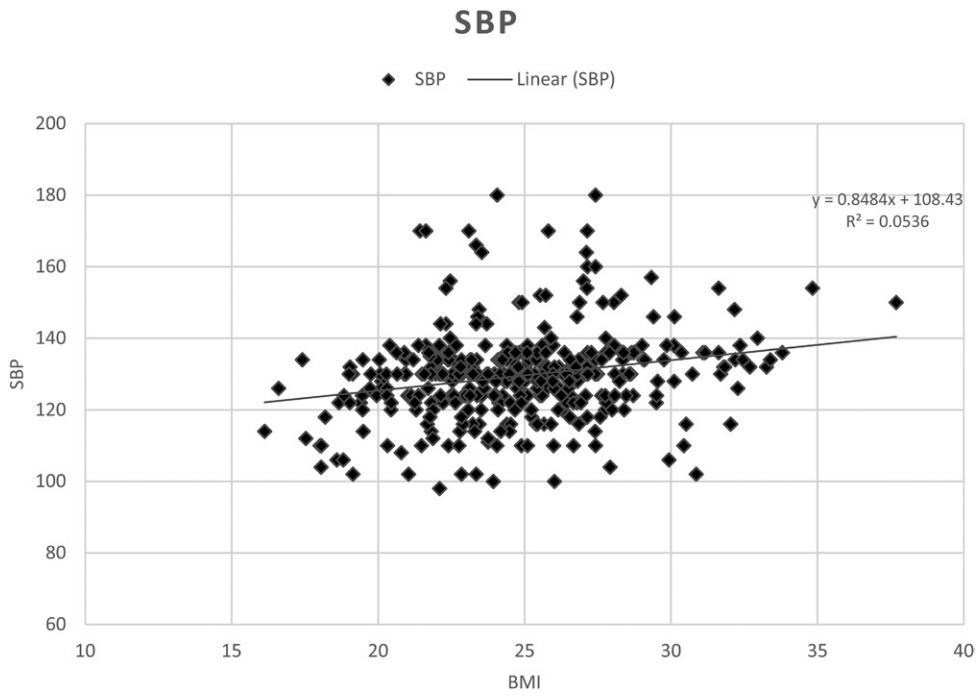

Fig. 2. Scatter diagram showing rise in systolic BP (SBP) as Body Mass Index (BMI) increases above 23.

when regional specific criteria were applied. The prevalence of hypertension (JNC VIII) among overweight or obese (WHO) pilots was 8.2% (33 out of 549), whereas that among normal BMI pilots was 1.9% (12 out of 636). When Asia-Pacific criteria were used, all hypertensives barring three were either obese or overweight. It was noted that as the BMI increased above 23, the prevalence of hypertension increased. Likelihood of HT increased with BMIs above 21.4 kg · m^{-2} as indicated by the receiver operating characteristic curve (**Fig. 4**).

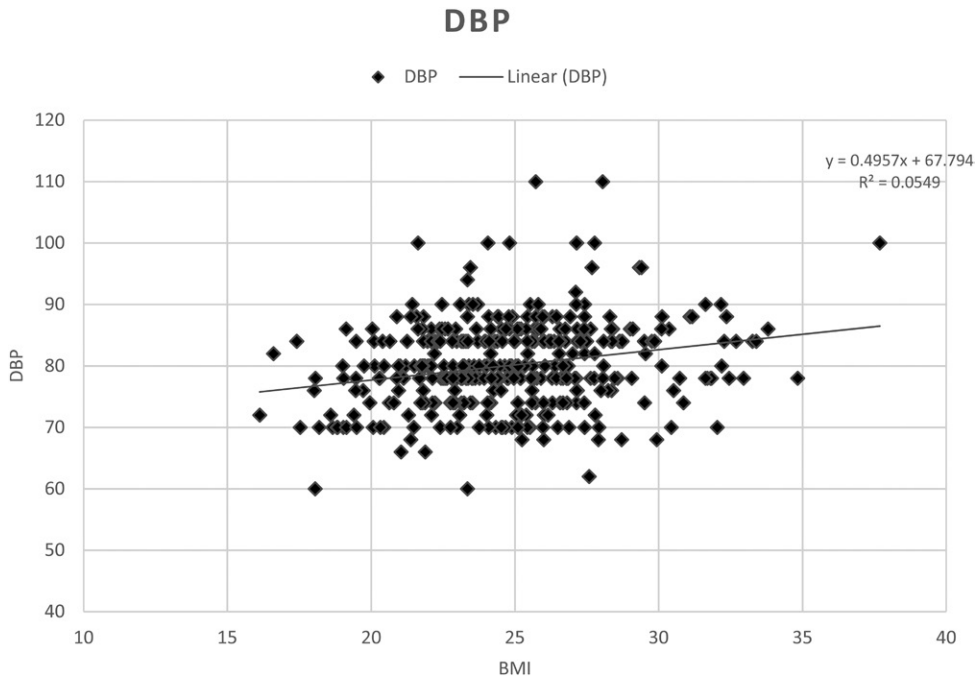

Fig. 3. Scatter diagram showing rise in diastolic BP (DBP) as Body Mass Index (BMI) increases above 23.

DISCUSSION

Although hypertension has been studied extensively in the general population, very few such studies have been conducted on aircrew and fewer still on aircrew in India. The prevalence of hypertension (as per the JNC VIII criteria) was 4.1% in our study, which is low compared to the general population, but similar to a Chinese study where it was 4.96%.[6] One common finding from many previous studies has been that pilots are healthier and have a lower prevalence of cardiovascular diseases as compared to the general population. This may be due to the regular, vigorous medical examinations and strict medical standards applicable to aircrew across the world, ensuring that only the fittest are cleared to fly (and therefore only the fittest are subjects of any study involving pilots). Previous studies have reported increasing incidence of hypertension among pilots with increasing age.[2,5] However, no such relation was noted in our study. Rather it was highest in the 26 to 35 yr age group, suggesting that this age group probably paid less attention to lifestyle measures than the previous generation.

Hypertension is one of the common reasons for a civilian pilot to be declared temporarily unfit for flying. As per the guidelines of the Directorate General of Civil Aviation in India, a blood pressure recording of 140/90 mmHg is accepted as the upper limit of normal blood pressure among pilots.[4] In case of mildly elevated readings, the DGCA Guidelines advise the collection of additional blood pressure data from serial clinic readings and ambulatory 24-h blood pressure monitoring. If the flight crew is confirmed to have hypertension, he/she is placed under observation and categorized as temporarily unfit for flying duties. During this period the pilot has to undergo further investigations

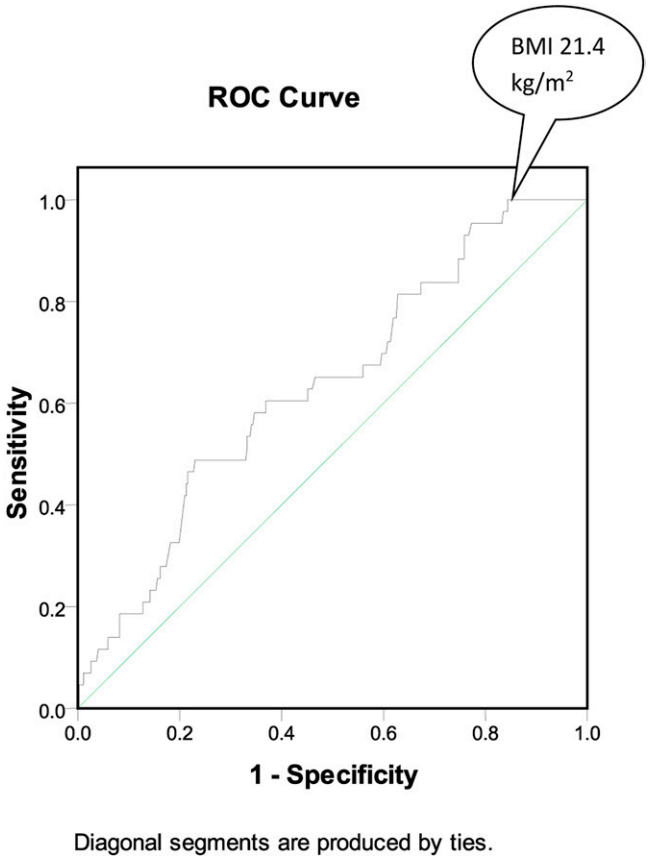

Fig. 4. Receiver operating characteristic (ROC) curve for having blood pressure >140/90 mmHg with variable Body Mass Index (BMI) (hypertension vs. BMI).

and treatment of hypertension. He/she is reviewed only 4 wk after blood pressure control is achieved and 24-h ambulatory blood pressure records show optimal control. He/she is allowed to fly again only if BP is well controlled and there are no side effects of the drugs.

In light of the new ACC/AHA criteria for diagnosing hypertension,[15] we studied the prevalence of hypertension using these criteria. It was 18.73% among pilots, which is alarmingly high. When we calculate 10-yr ASCVD risk, an additional 6.2% of pilots will require medication due to their increased ASCVD risk of more than 10% and face at least temporary unfitness for flying. There are a couple of published studies of hypertension in young adults using the new criteria.[11,20] These studies have shown that young adults with hypertension or elevated BP as per the new criteria are at increased risk of cardiovascular events in the future. A search of the literature did not reveal any data on prevalence of hypertension in pilots as per the new ACC/AHA criteria of November 2017. These additional 6.2% of pilots with HT as per the new criteria had 10-yr ASCVD risk >10%, but were allowed to fly as per current regulatory guidelines based on JNC 8 criteria. The risk of important cardiovascular complications like ischemic pain, embolic events, and arrhythmias increases with age, which can cause incapacitation or distraction and compromise flight safety.[8] Moreover, aircraft flying is often an exhilarating and catecholamine surging profession which can precipitate a cardiovascular event[8] in pilots with increased risk.

Civil pilots are responsible for the safety of hundreds of lives and it is imperative that they maintain the best health standards to prevent sudden in-flight incapacitation. Early detection and prompt treatment of hypertension is paramount in the interest of flight safety. Rising prevalence of obesity and hypertension do raise flight safety concerns since pilots with BP >130/80 and 10-yr ASCVD risk >10% are not under treatment or observation as per existing guidelines. Possibly the time has come to move to the new criteria for diagnosis and evaluation of hypertension among pilots in order to reduce the risk of adverse cardiovascular outcomes.

Analysis of data shows that as we move from the older JNC criteria to the more recent ACC/AHA criteria, the number of pilots with hypertension (on the first visit) rises from 129 (≥140/90) to 222 (≥130/80), i.e., rise from 10.9 to 18.73%, which adversely affects operational readiness. Moreover, 801 (67.6%) pilots were classified as having 'Elevated' BP and only 162 were normotensives (13.67%) under the ACC/AHA criteria as compared to 1056 (89.1%) normotensive pilots under the JNC VIII criteria. Thus, if we consider the ACC/AHA criteria, it puts a large number of pilots at risk of being labeled "hypertensive or having elevated BP." It is a well-known fact that office BP recordings are influenced by "White Coat Effect" wherein the recordings may be falsely high. At present, there is no guideline to record 24-h ABPM for BP values between 130–139 mmHg (systolic) and/or 80–89 mmHg (diastolic). Also, there is no cut-off for 24-h ABPM recordings to correspond and correlate with the new criteria for HT. The criteria/cut-off points for HT or otherwise after 24-h ABPM are well known for JNC VIII criteria. For obvious reasons, the same ABPM cut-offs cannot be used for diagnosing hypertension under the new criteria of 2017 since ABPM daytime mean cut-off for normal BP (135/85 mmHg) is much above the casual normal BP cut-off (130/80 mmHg) under the new ACC/AHA criteria. To be a meaningful evaluation, mean daytime ABPM cut off has to be <130/80. It has been observed in 24-h ABPM readings that the overall mean blood pressure is 5–10 mmHg less than casual recording (e.g., mean casual BP of those who underwent ABPM was 153.9/90.7 mmHg; average of 24-h ABPM was 146.5/85.6 mmHg). Hence an overall mean cut-off of 125/75 mmHg can be used to categorize as hypertension or not since that correlates well with casual BP of 130/80 mmHg.

The authors therefore suggest that pilots reporting for their annual medical evaluation should not be classified as hypertensive or normotensive directly as per the new criteria. Those having BP ≥130/80 mmHg should be further subjected to a 24-h ABPM. The overall mean of 24-h ABPM (thus excluding white coat effect) should be used to calculate 10-yr ASCVD risk and, thus, the need for treatment. This process will obviate unnecessary categorization of white coat hypertensives as hypertensives under the new criteria.

Since the disposal of this population of pilots with BP ≥130/80 but <140/90 is presently unclear (as per International Civil Aviation Organization/Federal Aviation Administration or DGCA, it is not hypertension), it is proposed that the ICAO guidelines be amended to institute lifestyle measures at BP of

≥130/80. Treatment of hypertension should be based only on mean of 24-h ABPM and 10-yr ASCVD risk. Moreover, we propose that a new cut-off for 24-h ABPM may be developed based on large scale studies. Meanwhile, a cut-off for overall mean of 24-h ABPM can be fixed at 125/75 mmHg to label individuals as hypertensive or not under new ACC/AHA criteria for reasons already elaborated.

Prevalence of obesity and overweight as per WHO criteria was 7.3% and 39%, respectively. These prevalence rates are similar to the obesity prevalence of 30–65% in urban areas in the country.[7] However, 46.3% of pilots were obese and 23.3% were overweight when Asia Pacific guidelines were used. The prevalence rate of obesity in pilots is less compared to that in the general population, where it was 56%,[12] since pilots as a group are healthier and physically fitter. As the BMI increased above 23 $kg \cdot m^{-2}$, both systolic BP and diastolic BP increased, although the coefficient of determination was modest and explains variability of BP and multifactorial causation. Considering that the likelihood of developing HT was 6.86 times higher when BMI was ≥23 $kg \cdot m^{-2}$, it is prudent to initiate lifestyle measures to combat overweight and obesity at BMI of 23 rather than at 25, which is the current practice.

In conclusion, hypertension is a common problem among pilots. The number will rise steeply if the new criteria of 2017 are applied. Overweight and obesity are also common and almost universal if Asia Pacific guidelines of BMI are applied. As the BMI increases above 23 $kg \cdot m^{-2}$, the likelihood of developing HT/WCH increases. Hence our practice of initiating lifestyle measures at BMI of 25 $kg \cdot m^{-2}$ needs to be changed to BMI of 23 $kg \cdot m^{-2}$. Similarly adopting new criteria for hypertension and initiating early treatment in those with increased 10-yr ASCVD risk goes a long way in preventing cardiovascular disease and in improving flight safety.

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