Annales Africaines de Médecine
Article original

Hypertension and Associated Cardiometabolic Risk Factors among Civilian Aircrew

Hypertension et facteurs de risque cardiométabolique chez le personnel navigant civil

Nathan Bimbi Buila[1,2], Gilbert Kurhega Kabanda[1], Jean-Marc Bimbi Bantu[3], Georges Ndumba Ngoyi[1], Trésor Sengi Mvunzi[1], Noël Onembo Otshudi[1], Yves Nsimbi Lubenga[1], Pascal Mwasa Bayauli[1,4], Patrick Kalambay Kayembe[5], François Bompeka Lepira[1,6], Symphorien Mpandamadi Ditu[4], Jean-René M'Buyamba-Kabangu[1]

Correspondence
Jean René M'Buyamba-Kabangu, *MD, PhD*
Courriel : jerembu@yahoo.fr

Résumé
Contexte et objectif. Les facteurs de risque cardiométaboliques n'ont pas encore été étudiés entre Personnel Navigant Technique (PNT) et Commercial (PNC). L'étude a évalué la prévalence de l'hypertension (HTA), ses déterminants et les facteurs de risque cardiométaboliques associés chez les PNTs et PNCs. ***Méthodes***. L'analyse médicale pour le renouvellement de certificat de classe 1 ou 2 selon l'OACI a concerné 379 personnes navigants ; 112 femmes (29,6%) et 88 caucasiens (23,2%). De 237 PNTs, 175 étaient des pilotes (46,2%) et 142 PNCs (35,5%). ***Résultats***. Plus répandue (32,4% vs 13,1%; p <0,001) parmi les PNTs que les PNCs, l'HTA chez le personnel navigant était dans la plupart des cas non diagnostiquée, non traitée et non contrôlée. La prévalence du surpoids/obésité (72,4% vs 53,6%; p = 0,001), de l'athérosclérose infraclinique (13,5% vs 4,1%; p = 0,006), de la dyslipidémie (61,4% vs 47,1%; p = 0,009), de l'HVG (14,4% vs 3,0%; p <0,001), et du risque cardiovasculaire élevé (21,7% vs 12,9%; p = 0,045) était plus majorée parmi les PNTs. Le risque de présenter l'HTA augmentait avec la catégorie PNT (aOR: 4,96; IC 95%: 2,16-11,38; p <0,001), l'adiposité abdominale (aOR: 2,51; IC 95%: 1,19-5,30; p = 0,015), le surpoids / obésité (aOR: 2,88; IC 95%: 1,22-6,77; p = 0,016), l'athérosclérose infraclinique (aOR: 5,10; IC 95%: 1,99-13,10; p = 0,001), la tachycardie (aOR: 2,62; IC 95%: 1,01) - 6,79; p = 0,049) et l'HVG (aOR: 4,90; IC à 95%: 1,29-18,62; p = 0,02). ***Conclusion***. La profession PNT est associée à une prévalence plus élevée de l'HTA et à des facteurs de risque cardiométaboliques associés, ce qui souligne la nécessité d'un programme complet de prévention et de soins pour cette catégorie particulière du personnel navigant civil.

Mots-clés: facteurs de risque cardiovasculaire, hypertension, obésité, Personnel navigant, pilote
Reçu le 3 mars 2019 ; Accepté le 7 mai 2019

1 Cardiology and Hypertension Unit, UNIKIN; DRC. 2 Civil Aviation Authority, DRC. 3 Cardiology, Chirec Clinics, Brussels, Belgium. 4 Endocrinology and Metabolic Diseases, UNIKIN, DRC. 5 School of Public Health, UNIKIN, DRC. 6 Nephrology, UNIKIN, DRC

Summary

Context and objective. Cardiometabolic risk factors profile of flight and cabin crew has never been previously assessed in low-resource settings such as sub-Saharan African countries. The present study aimed to evaluate the prevalence of hypertension, its determinants, and associated cardiometabolic risk factors among flight and cabin crew. ***Methods***. A total of 379 aircrew members, 112 women (29.6%) and 88 Caucasians (23.2%) of whom 237 flight crew (62.5%) including 175 pilots (46.2%) and 142cabin crew (35.5%) underwent a medical examination for either initial or renewal medical certificate Class I or II as per the ICAO and the CAA/DRC recommendations including blood chemistry, ECG, and echocardiogram. ***Results***. Much more prevalent (p<0.001) among flight than cabin crew (32.4% vs 13.1%), hypertension in these civilian aircrew was in most cases undiagnosed, untreated, and therefore uncontrolled. The prevalence of overweight/obesity (72.4% vs 53.6%; p=0.001), subclinical atherosclerosis (13.5% vs 4.1%; p=0.006), dyslipidemia (61.4% vs 47.1%; p =0.009), left ventricular hypertrophy (14.4% vs 3.0%; p<0.001), and high cardiovascular risk estimate (21.7% vs 12.9%; p=0.045) predominated among flight crew. The odds of hypertension increased with aircrew category (aOR for flight vs cabin crew: 4.96; 95% CI: 2.16-11.38; p<0.001), abdominal adiposity (Present vs absent (2.51 1.19 - 5.30; p=0.015), overweight/obesity (aOR: 2.88; 95%CI: 1.22-6.77; p =0.016), subclinical atherosclerosis (aOR: 5.10; 95%CI: 1.99-13.10; p = 0.001), fast heart rate (aOR: 2.62; 95%CI: 1.01-6.79; p =0.049), and LVH (aOR: 4.90; 95%CI: 1.29-18.62; p =0.02). ***Conclusion***. Fight crew is associated with higher prevalence of hypertension and associated cardiometabolic risk factors highlighting the need for a comprehensive prevention and care program for this particular category of Civilian Aircrew.

Key words: Cardiovascular risk factors, hypertension, obesity, aircrew

Received: March 3rd, 2019
Accepted: May 7th, 2019

Introduction

Hypertension is the first issue for pilots to secure their medical certificate (1). Raised blood pressure is a sizeable avoidable driver of the global burden of disease, accounting for at least 10 million of deaths in 2017 (2). Through complications such as myocardial infarction, stroke, renal failure and death, hypertension might constitute a risk factor for inflight incapacitation. In-flight cardiovascular (CV) events are believed to be scarce (3) although allegation of in-flight CV incapacitation misdiagnosis has once been put forth. Such a scarcity appears in line with the ICAO recommendation for aeromedical specialists to diagnose CVD before it appears (4). Unfortunately, only a few studies have so far focused on the prevalence of CV risk factors such as hypertension, obesity, left ventricular hypertrophy (LVH), etc. among aircrew.

In the Democratic Republic of the Congo (DRC) as elsewhere in sub-Saharan Africa, no such assessment has ever been undertaken. We took advantage of the activities of the aeromedical centers appointed by the Civil Aviation Authority (CAA)/DRC to issue aeromedical certificates in order to assess the prevalence of hypertension, its determinants, and associated cardiometabolic risk factors among licensed aircrew operating in DRC by comparing data of flight and cabin crew.

Methods

The current survey was carried out from June 1st to December 31st, 2015 among aircrew who attended Congolese authorized AMC to apply for aircrew medical certificate. According to CAA/DRC regulations, pilots and flight engineers must respectively bear a valid class I and class II medical certificate, and cabin crew a class II certificate additionally to ICAO regulations. These documents are renewed once or twice yearly for pilots, once every two years for flight engineers and cabin crew.

We collected information about age, gender, total flight time, aircrew license, lifestyle habits (alcohol and tobacco intake, and physical activity), history and current treatment for chronic diseases (hypertension and type-2 diabetes mellitus (T2DM)). We obtained measurements of height (tape measurer, cm), weight (FAZZINI scale/Italy, kg), waist (WC) and hip circumferences at the nearest 0.5 cm. WC was measured in standing position at the least respiration and at the partway of the inferior rib margin and the anterior superior iliac crest. Body mass index (BMI) was weight in kilograms divided by the square of height in meters. After the subject has been seated for at least 5 minutes in a quiet room on a restful chair, three consecutive blood pressures (BP) measurements were obtained using a validated monitor (OMRON M6, HEM 7001) with appropriate cuff size fastened at the upper right arm. The average of the last two measures was used for analysis.

We assessed heart rate (HR) by resting 12-lead electrocardiogram (ECG) and computed heart rate corrected QT interval as QTC = QT +1.75 (HR-60). On a 2D echocardiography (GE Logic 5), we obtained left ventricle (LV) internal diameters (LVIDd and LVIDs), posterior wall thickness (PWTd and PWTs), interventricular septum thickness (STd and STs) at end diastole and systole, and left atrial (LA) diameter. We calculated LV mass (LVM) as $LVM = 0.8 \times \{1.04\ [(LVIDd + PWTSWTd)^3 - (LVIDd)^3]\} + 0.6g$, and LVM indexed (LVMI) as LVM divided by body surface area reckoned as the squared root of the product of weight (in kg) and height (in cm) divided by 60. The relative wall thickness (RWT) was twice the ratio of PWTd to LVIDd (5). Pulsed-wave Doppler technique helped to measure early diastolic mitral inflow velocity (E), late diastolic mitral inflow velocity (A), and deceleration time (DcT) of E, which is the time interval from the peak to the decline of E-wave. We calculated E/A ratio, which was used with DcT to assess diastolic dysfunction (6).

Five milliliters of blood were collected by clean antecubital venipuncture after a 12-h fast and the plasma for subsequent analysis of total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-c), high-density lipoprotein cholesterol (HDL-c), glucose, blood urea nitrogen (BUN), creatinine, and uric acid (UA). Low-density lipoprotein cholesterol (LDL-c) was computed using the Friedewald formula. We also obtained a freshly voided urine sample for qualitative proteinuria.

We categorized aircrew as flight (Pilots and flight engineers) and cabin crew who, as per the CAA/DRC's recommendations, must hold a license to carry out aviation duty. People with weekly physical activity of 2 hours or less were categorized as physically unfit. We defined drinking and smoking habits by the notion of alcohol or tobacco use at least once per week during the past year. Overweight and obesity were BMI between 25 $kg.m^{-2}$ and 30 $kg.m^{-2}$ or more than 30 $kg.m^{-2}$ (7). We used ethnic group specific cut-points to assess abdominal adiposity in the Africans as WC >94 cm in men and > 80 cm in women, and in the Caucasians as WC>102 cm in men (7). In accordance with the 2013 ESH/ESC guidelines, hypertension was a BP of at least 140 mmHg systolic and/or 90 mmHg diastolic, and/or use of high BP lowering drugs (8). Pulse pressure (PP) was the difference between systolic (SBP) and diastolic blood pressure (DBP). Subclinical atherosclerosis was the PP of 60 mmHg or more. T2DM was a fasting blood glucose > 126 $mg.dL^{-1}$, a self-reported diagnosis, and/or a use of hyper-glycemic lowering medications. Hyper-cholesterolemia was a TC>190 mg/dL or use of lipid lowering drugs. Dyslipidemia was based on the concomitant presence of the following features: triglycerides > 150 $mg.dL^{-1}$, LDL-cholesterol ≥ 100 $mg.dL^{-1}$, HDL-cholesterol less than 50 $mg.dL^{-1}$ (women) or 40 $mg.dL^{-1}$ (men), or the presence of hypercholesterolemia (9). We defined metabolic syndrome as the presence of abdominal adiposity associated with at least two of the following characteristics: BP > 130/85 mmHg and/or use of high blood pressure lowering drugs; fasting blood glucose > 100 $mg.dL^{-1}$ and/or diagnosed T2DM; serum triglycerides > 150 $mg.dL^{-1}$ or use of lipid lowering drugs; HDL cholesterol < 50 $mg.dL^{-1}$ in women or < 40 $mg.dL^{-1}$ in men (9). To compute the estimated glomerular filtration rate (eGFR), we used the Modification of Diet in Renal Disease (MDRD) with respect to the race and the sex of the aircrew (10). We scored proteinuria as + or higher using a dipstick test (Medi Test Combi 9, Düren, Germany) on freshly voided urine specimens. LVMI more than 110 g/m², 125 g/m² or 51 g/m². 7 in women, men or both sexes were considered echocardiographic-based LVH, respectively. When integrating higher LVMI with RWT, we classified LVH as either concentric (RWT greater than 0.42) or eccentric (RWT less than 0.42). Concentric remodeling was present when LVMI was normal with increased RWT. Tachycardia was defined as ECG-based heart rate faster than 90 beats/min. We defined LV diastolic dysfunction by E/A ratio less than 0.8 and/or DcT more than 200 ms. We estimated atherosclerotic CVD (ASCVD) risk using the Framingham scoring equations (11).

The ethical committee of the Public Health School of the University of Kinshasa approved this protocol. We did not request individual aircrew's consent given that information from this survey was confidently managed with respect for the sake of privacy.

Statistic methods

Because of significant variance in age distribution between the aircrew professional categories, we age-adjusted means of continuous variables and that of categorical variables using the GLM and logistic regression analysis by Genmod procedures, respectively. The Student's t-test was used to compare means and the Pearson's Chi-square or Fisher's exact test as appropriate for proportions. Logistic regression analysis was used to assess independent determinants of hypertension; adjusted odd ratio values and 95% confidence intervals were determined. Variables considered in the analysis were: ethnicity (Africans vs Caucasians), professional category (flight vs cabin crew), subclinic atherosclerosis (present vs absent), abdominal adiposity (present vs absent), overweight/obesity (present vs absent), elevated resting heart rate (present vs absent), LVH (present vs absent), and LV diastolic dysfunction (present vs absent). Analyzes were performed using the Statistical Package for Social Sciences (SPSS Inc., Chicago, IL) version 17.0, and the significance level was set at p <0.05.

Results

The study population comprised 379 subjects: 237 flight (62.5%) and 142 cabin crew members (37.5%); 112 women (29.6%) and 88 Caucasians (23.2%). Flight crew was made of 175 (46.2%) first- and second-class licensed pilots, and 62 (16.2%) flight engineers. The general characteristics of the study population are summarized in Table 1. Age averaged 41±13 y (rang: 19 to 70 y) with flight crew older (P< 0.001) than cabin crew. Compared to cabin crew, age –adjusted SBP, DBP, weight, height, waist and hip circumferences, eGFR and ASCVD risk estimate were higher (P<0.005) whilst HDL-cholesterol was lower (P<0.001) in flight crew; average levels of BUN, creatinine, total cholesterol, LDL-cholesterol, triglycerides, fasting glucose and serum UA were similar in the two professional categories.

Values are mean ± STD, LDL: low-density lipoprotein; HDL: high-density lipoprotein, CVD: cardiovascular diseases. The 12-lead ECG and 2D echocardiography features of flight and cabin crew are compared in Table 2. Whilst age-adjusted heart rate, QRS duration, QTc interval, RWT, LVEFc, E/A ratio, and DT were on average similar in the two aircrew categories, the Cornell index, LVMI, ST, PWT, and LA, ventricular and ascending aorta diameters were greater among flight crew. Only 42 individuals (11.1%) were free of CV risk factors the number of which amounted to one, two, three, four or more in 108 (28.5%), 136 (35.9%), 71 (18.7%), and 19 (5.0%) aircrew members, respectively.

Table 3 summarizes the prevalence of various cardiometabolic risk factors according to professional categories and gender. Flight crew had higher prevalence of hypertension (32.4% vs 13.1%; p<0.001), overweight/obesity (72.4% vs 53.6%; p=0.001), subclinical atherosclerosis (13.5% vs 4,1%; p=0.006), dyslipidemia (61.4% vs 47.1%; p=0.009), alcohol (70.9% vs 64.1%; p=0.003) and tobacco use (25.7% vs 13.4%; p=0.004), but lower rates of abdominal adiposity (55.6% vs 68.6%; p=0.017) and CKD (2.6% vs10.0%; p=0.004) than cabin crew. Similarly, men had higher prevalence of tobacco (25.8 vs 9.8%, p<0.001) and alcohol use (71.2 vs 61.6), hypertension (34.1 vs 5.4%, p<0.001), subclinical atherosclerosis (13.5 vs 4.6%, p<0.002), overweight/obesity (72.3 vs 35.7%, p<0.001), tachycardia (7.1 vs 3.6, p<0.027), and LVH (12.0 vs 3.6%, p <0.006), but lower prevalence of abdominal adiposity when compared to women. The difference in the other cardiometabolic risk factors was not significant. Amongst the hypertensive individuals, 21 (21.6%) were aware of their condition; 11(52.4%) were treated. In addition to the non-pharmacological measures, 7(33.3%) individuals received antihypertensive drugs. No one had BP at the target level of below 140/90 mmHg. Hypertension was an isolated condition in 6 (6.2%) individuals. It was associated with one, two, three, four or more other CV risk factors in 13 (13.4%), 39 (40.2%), 25 (25.8%), and 14 (14.4%) subjects, respectively. All individuals with T2DM but 2 (0.5%) were aware of their disease.

In univariate analysis, the odds of hypertension increased with ethnicity (Caucasian vs African 2.08 [1.23-3.52]; p=0.007), professional category (flight vs cabin crew 7.66 [3.82-15.34]; <0.001), subclinic atherosclerosis (present vs absent 7.01 [3,48-14,12]; p<0.001), abdominal obesity (present vs absent; 14.15 [2.36-7.28]; p<0.001), overweight/Obesity (present vs absent; 7.18[23,68-14,03]; p<0.001), faster heart rate (present vs absent; 5.85[2.56-9.61]; p=0.047), LVH (present vs absent; 11.90 [4.26-

33.17]; p<0.001), and LV diastolic dysfunction (present vs absent; 2.23 [1.09-4.58]; p=0.004). In multivariable adjusted analysis, only professional category (Odd ratio for flight vs cabin crew; 2.51 [1.19-5.30]; p<0.001, subclinic atherosclerosis (present vs absent; 5.10 [1.99-13.10]; p<0.001), abdominal obesity (present vs absent; 2.51 [1.19-5.30]; p=0.015), overweight/obesity (present vs absent; 2.88 [1.22-6.77]; p=0.016), faster heart rate (present vs absent; 2.62 [1.01-6.79]; p=0.049), and LVH (present vs absent; 4.90 [1.29-18.62]) emerged as independent correlated of hypertension (Table 4).

Discussion

The main finding of the present survey is that flight crew had higher prevalence of hypertension and associated cardiometabolic risk factors than cabin crew highlighting the difference in the deleterious impact of categorized aeronautical duties on the CV system.

At least one out of four aircrew members had hypertension in the current study; the crude hypertension prevalence in flight crew was five times higher than that in cabin crew. The odds of hypertension increased with flight crew, abdominal adiposity, overweight/obesity, subclinic atherosclerosis, faster heart rate and presence of LVH. Exposure to flight stress could be listed as a plausible explanation as weighted by total flight time at baseline. Indeed, considering the responsibility to fly the plane, flight crew is exposed to chronic stress that might trigger both hypothalamo-pituitary-adrenocortical and sympatho-adreno-medullary pathways to raise arterial BP (12). Likewise, Lüders S *et al*. found in the STARTLET project that mental exhaustion was linked with variations in BP in people from sundry working places (13). In addition, Marvar *et al*. reported that chronic stress could lead to hypertension, which is triggered by angiotensin II through either lymphocyte T activation or vascular inflammation (14). On the other hand, flight crew remains seated while cabin crew may move to care of passengers. Puttonen S *et al*. showed that cabin crew do not have high CVDs compared with other workers due to periodical consistent check-ups (15). Nearly two over five pilots had hypertension. This contrasts with the 7% reported by Arteaga LF *et al*. (16) among civilian aviation pilots in Colombia. Most of hypertensive aircrew were undiagnosed and untreated, and no one was controlled. This observation is consistent with the globally sub-Saharan African dire reality of deficient awareness, poorer detection and lower management of hypertension, which is accountable for early occurrence of chronic organ damage (17).

The prevalence of subjects with a faster resting heart rate in our study is of the same magnitude as the 6.8% observed in a normative sample from the ’’First U.S. National Health and Nutrition Examination Survey (NHANES I)’’ data (18). In our study, it was nearly five times more frequent in flight than in cabin crew. Several clinical and epidemiological reports have suggested that fast resting heart rate, as a marker of sympathetic nervous system and renin angiotensin system overactivity, is a powerful independent predictor not only of cardiovascular, but also of all-cause mortality. Faster heart rate at rest could be associated, through oxidative stress and subsequent inflammation, with development of atherosclerosis, progression of heart failure, and enhancement of myocardial ischemia or infarction (19).

Our study also showed overweight/obesity to predominate among flight than cabin crew. Sundry authors documented that obesity, singularly of abdominal localization, is strongly associated with hypertension, stroke, coronary heart disease, cardiac heart failure and arrhythmias. The mechanism is both complex and multifactorial, encompassing hemodynamic, metabolic and endocrine pathways (20). Obesity can alter cardiac hemodynamic, which triggers LVH through an increased afterload to left ventricle. LVH is a well-known independent predictor of morbidity and mortality including disabling events such as sudden death, myocardial infarction and stroke. In the present work, LVH was to predominate among flight than cabin crew and was associated with elevated serum UA level. Recently, Grossman *et al*. indicated that instead of being a consequence of hypertension, interventricular septum thickening might predict the occurrence of high SBP among fit airmen (21). LVH combined with elevated serum UA is an independent and powerful predictor of CVDs. Such a relationship has been emphasized in both experimental and in vitro studies where higher serum UA appeared to induce cardiac hypertrophy via inflammatory mediators such as TNF and mitogen-activated protein kinases (22).

The self-reported prevalence of tobacco use in flight crew was twice the rate observed in cabin crew and nearly five times than seen in the Congolese general population (23). Our results contrast with those in UK commercial pilots whose prevalence of smoking was significantly lower than that in the general population (24). Smoking enhances the risk of stroke, heart and peripheral artery disease (25) and has been documented to induce heart rate variability and abnormalities related to CV outcomes of which the underlying mechanism is not fully understood. The proportion of aircrew with risk factors not at recommended levels was significantly greater in flight crew when compared with cabin crew. At variance with the ”work-effect” (24) indicating that pilots had lower CV risk factors when compared with the general population, we found the crude prevalence of abdominal adiposity, overweight/ obesity and self-reported tobacco and alcohol use to be higher among flight crew. The crude prevalence was similar for hypertension, T2DM, and physical inactivity. When we considered African pilots as a singular group, their hypertension crude prevalence was higher than that of the Congolese general population (23). Differences in age and gender, socio-economic and education status could explain discrepancies between cardiovascular risk factors among aircrew and the general population. Because aviation personnel access to the same periodically healthcare program, the variances observed between flight and cabin crew, and even between airmen and the general population might possibly express differences in the non-adherence and non-compliance to prescribed treatment as well as the nascence of aeromedical practices in DRC.

Our study has potential limitations and some strengths. Firstly, we used office-based hypertension definition that is influenced by the white-coat effect and is less sensitive risk predictor of hypertension organ target compared to ambulatory BP monitoring (ABPM). Secondly, we did not assess the stress level in flight and cabin crew. Nonetheless, we used cabin crew, another aviation occupational group as the reference population, to assess the cardiometabolic risk factors in flight crew and we made personal contact with the aircrew participating in our study.

Conclusion

In the present study, flight crew represent a high CVD risk subgroup requiring development of a comprehensive prevention and care program to mitigate the elevated risk and improve their quality of life and performance. The current results further indicate linked to clustering of hypertension with various cardiometabolic risk factors, a higher global risk of cardiovascular disease among flight crew, the prevention of which is mandatory to ensure the flight safety.

Acknowledgements

We express our thanks to Mr. Jean Tshiumba, GM of the CAA/DRC and his administration for their full support and to Mr. Joseph Kangudia, MD, BGen and GM of AMC-African Union Presidential Medical Center and his team, for their astonish work. With appreciation, we acknowledge Dr Aliocha N Nkodila for data analysis.

Funding
No specific grant or other support received.

Conflict of interests
None declared.

Contributors
NBB, FBL, and JRMK conceived the study protocol and contributed to data analysis and manuscript writing. NBB drafted the 1st manuscript. GNN, OON, YNL, NNG, TSM, NOO, and KTZ collected and interpreted data. GKK, JMBB and DMS interpreted data. KKP interpreted data and conducted data analysis. All authors assented to the final version and had full entrée to all the data of the survey. JRMK had the conclusive duty for the decision to submit the paper and is the guarantor.

References

1. De John CA, Wolbrink AM, Larcher JG. In-flight medical incapacitation and impairment of airline pilots. *Aviat Space Environ Med* 2006; **77**: 1077- 1079.
2. GBD 2017 Risk Factor Collaborators. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet* 2018;**392**: 1923-1994.
3. Ekstrand K, Boström P-A, Arborelius M, Nilsson J-Å, Lindell S-E. Cardiovascular Risk Factors in Commercial Flight Aircrew Officers compared with those in the General Population. *Angiology* 1996; **47**: 1089 – 1094.
4. Taneja N, Wiegmann D. Prevalence of cardiovascular abnormalities in pilots involved in fatal general aviation airplane accidents. *Aviat Space Environ Med* 2002; **73**:1025-1030.
5. Barbieri A, Bursi F, Mantovani F, Valenti C, Quaglia M, Berti E *et al*. Prognostic impact of left ventricular mass severity according to the classification proposed by the American Society of Echocardiography/European Association of Echocardiography. *J Am Soc Echocardiogr* 2011; **24**:1383–1391. doi: 10.1016/j.echo. 2011.08.012.
6. Nagueh SF, Smiseth OA, Appleton CP, Byrd BF, Dokainish H, Edvardsen T *et al*. Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. *Eur Heart J Cardiovasc imaging*. 2016; **17** (12):1321-1360.
7. Finucane MM, Stevens GA, Cowan M, Danael G, Lin JK, Paclorek CJ *et al*. National, regional, and global trends in body mass index since 1980: Systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9.1 million participants. *Lancet* 2011; **377** (9765):557-567. doi:10.1016/ S0140-6736 (10) 62037-62045.
8. 2013 ESH/ESC Guidelines for the management of arterial hypertension: The Task Force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC), *European Heart Journal* 2013, **34** (28): 2159–2219. 10.1055/s-2006-956252.
9. Alberti KGMM, Eckel RH, Grundy SM, Zimmet PZ. Cleeman JL, Donato KA *et al*. Harmonizing the Metabolic Syndrome: A Joint Interim Statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; Arnerican Heart Association; World Heart Federatiorr; International Atherosclerosis Society; and International Association for the Study of Obesity. *Circulation*, 2009; **120**: 1640-1645. doi.orgjlO.1161/CIRCULÂflONAHA.109. 192644
10. Levey A, Coresh I, Greene T *et al*. Using standardized serum creatinine values in the Modification of Diet in Renal Disease Study equation for estimating glomerular flftration rate. *Ann lntern Med* 2006; **145**: 247-254.
11. D'Agostino RB Sr, Vasan RS, Pencina MJ, Wolf PA, Cobain M, Massaro JM, Kannel WB. General Cardiovascular Risk Profile for Use in Primary Care: The Framingham Heart Study. *Circulation* 2008; **117**:743-753. doi:10. 1161/ circulationaha.107.699579
12. Rutledge T, Hogan BE. A quantitative review of prospective evidence linking psychological factors with hypertension developfnent. *Psychosom Med* 2002; **64**: 758—766.
13. Lüders S, Hammersen F, Kulschewski A, Frerichs A, Frieg R, Hahnheiser D *et al*. Stress-associated hypertension in the work place: resulta al the STARLET project. *Dtsch Med Wochenschr* 2006 Nov 17; **131**(46): 2580-5. doi: 10.1055/s-2006-956252
14. Marvar PJ, Harrison DG. Stress-Dependent Hypertension and the Role of T Lymphocytes. *Exp Physiol* 2012; **97** (11): 1161–1167. doi: 10.1113/expphysiol.2011.061507

15. Puttonen S, Viitasalo K, Härmä M. The relationship between current and former shift work and the metabolic syndrome. *Scand J Work Environ Health* 2012; **38** (4):343-348. https://www.jstor.org/stable/41508901
16. Arteaga-Arredondo LF, Fajardo-Rodríguez HA. Cardiovascular Risk Factor Prevalence in civil aviation pilots in Colombia During 2005. *Rev Salud Publica* (Bogota) 2010; **12** (2):250-256. doi: 10.1590/S0124-00642010000200008
17. M'Buyamba – Kabangu JR, Biswika T, Thijs L, Tshimanga GM, Ngalula FM, Disashi T. *et al*. In-hospital mortality among Black patients admitted for hypertension-related Disorders in Mbuji Mayi, RD Congo. *Am J Hypertens* 2009; **22**: 643-648. doi: 10.1038/ajh.2009.47.
18. Ostchega Y, Porter KS, Hughes J, Dillon CF, Nwankwo T. Resting pulse rate reference data for children, adolescents, and adults: United States, 1999–2008. *Natl Health Stat Report* 2011;**41**:1–16.
19. Fox K, Borer JS, Camm AJ, Danchin N, Ferrari R, Lopez Sendon JL, *et al*. Heart Rate Working Group. Resting heart rate in cardiovascular disease. *J Am Coll Cardiol* 2007; **50** (9):823–30. doi: 10.1016/j.jacc.2007.04.079
20. Poirier P, Giles TD, Bray GA, Hong Y, Stern JS, Pi-Sunyer X *et al*. Obesity and Cardiovascular Disease: pathophysiology, evaluation, and effect of weight loss. *Arterioscler Thromb Vasc Biol* 2006; **26** (5):968-976. doi:10.1161/01.atv.0000 216787.85457.f3
21. Grossman C, Grossman A, Koren-Morag N, Azaria B, Goldstein L, Grossman E. Interventricular Septum Thickness Predicts Future Systolic Hypertension in Young Healthy Pilots. *Hypertens Res* 2008; **31** (1): 15–20. doi: 10.1177/1741826 710389417.
22. Staessen J. The determinants and prognostic significance of serum uric acid in elderly patients of the European Working Party on High Blood Pressure in the Elderly trial. *Am J Med*. 1991; **90**:50S–54S.
23. Bayauli PM, M'Buyamba-Kayamba JR, Lemogoum D, Thijs L, Dramaix M, Fagard R, *et al*. Cardiovascular Risk Factors among the Inhabitants of an Urban Congolese Community: Results of the VITARAA Study. doi: 10.1016/ j.ijcme.2014.07.003
24. Houston S, Mitchell S, Evans S. Prevalence of cardiovascular disease risk factors among UK commercial pilots. *Eur J Cardiovasc Prev Rehabil 2011*; **18** (3):510–517. doi:10.1177/ 1741826710389 417
25. Fowkes FGR, Housley E, Rudolph A. Riemersma RA, Macintyre CCA, Cawood EHH, *et al*. Smoking, Lipids, Glucose Intolerance, and Blood Pressure as Risk Factors for Peripheral Atherosclerosis Compared with Ischemic Heart Disease in the Edinburgh Artery Study. *Am J Epidemiol* 1992; **135**: 331–340. doi: 10.1093/ oxfordjournals.aje.a116294

Table 1. General characteristics of the aircrew by professional categories

Characteristics	All	Flight crew	Cabin crew	p
n(%)	379 (100)	237 (62.5)	142 (37.5)	
Age, years	38.0(36.0-41.0)	45.0(43.0-49.0)	32.0(30.0-33.0)	<0.001
Systolic blood pressure, mmHg	121.7±17.9	128.9±16.6	117.1±13.7	<0.001
Diastolic blood pressure, mmHg	77.3±10.9	81.0±10.5	75.8±10.9	<0.001
Pulse pressure, mmHg	44.4±11.90	47.8±11.4	41.3±7.5	<0.001
Weight, kg	79.1±15.6	85.1±14.5	68.9±11.9	<0.001
Height, cm	172.4±7.6	174.8±6.9	168.2±6.8	<0.001
Body mass index, kg/m²	26.5±4.5	27.8±4.2	26.6±3.9	0.006
Waist, cm	92.7±11.3	97.1±10.1	94.3±8.4	0.005
Hip, cm	104.5±9.8	106.7±10.2	106.4±6.9	0.756
Waist-hip-ratio	0.89 ±0.07	0.91±0.07	0.88±0.05	<0.001
Urea, mg.dL^{-1}	25.1±10.7	24.3±10.2	26.5±11.6	0.081
Creatinine, mg/dL	1.06±0.2	1.1(0.2)	1.05±0.3	0.737
Estimated GFR, mL/min/1.73 m²	96.2±24.8	94.1±20.2	87.9±22.2	0.006
Fasting glucose, mg/dL	86.0±19.0	85.6±20.2	82.9±16.7	0.181
Total cholesterol, mg/dL	171.9±43.5	170.7±45.8	177.5±42.1	0.15
Uric acid, mg/dL	6.2±1.8	6.3±1.9	6.3±1.9	0.999
HDL-cholesterol, mg/dL	62.5±22.3	59.8±20.6	69.8±16.2	<0.001
LDL-cholesterol, mg/dL	86.7±47.9	89.2±42.5	87.5±41.7	0.705
Triglycerides, mg/dL	101.4±75.7	101.9±70.1	93.9±68.5	0.279
Estimate 10-y risk for CVD	9.4±9.0	13.0±9.5	3.4±3.0	<0.001

Table 2. Electrocardiographic and echographic characteristics of the aircrew by professional categories

Characteristics	All n=379	Flight crew n=237	Cabin crew n=142	p
Electrocardiogram profiles				
Heart rate, bpm	69.6±12.9	70.5±14.8	70.1±7.5	0.765
QRS, ms	83.2±16.9	84.7±15.9	81.5±20.2	0.077
Corrected QT interval, mSec	384.6±33.3	389.2±32.6	387.8±33.2	0.688
Cornell index, ms	1.2±0.6	1.3±0.7	0.99±0.36	<0.001
Echocardiographic profiles				
Ascending aorta, mm	30.4±4.3	31.5±4.0	29.8±3.4	<0.001
Left atrial diameter, mm	31.4±4.5	32.6±4.2	31.2±3.4	0.001
Left ventricle internal diameter, mm	23.4±3.6	24.1±4.0	22.8±3.2	0.001
Septum thickness, mm	16.5±1.9	16.9±2.0	15.5±1.2	<0.001
Posterior wall thickness end diastolic, mm	15.9±1.8	16.2±1.9	15.4±1.2	<0.001
Relative wall thickness	0.39±0.7	0.39±0.07	0.39±0.07	0.998
Left ventricle mass Indexed, gram	77.2±26.8	83.7±26.9	77.6±26.4	0.032
Left ventricle ejection fraction corrected	78.6±4.7	78.6±5.4	79.3±3.5	0.168
E/A ratio	1.1±0.1	1.1±0.1	1.1±0.1	0.998
Deceleration time, mSec	177.5±15.8	177.9±16.3	176.7±18.9	0.514

Values are mean ± STD, Bpm: beat per minute; mSec: millisecond; mm: millimeter

Table 3. Cardiovascular Risk factors among aircrew by professional and gender categories

Characteristics	All n=379	Profession			Gender		p-value
		Flight crew (n=237)	Cabin crew (n=142)	p-value	Men n=267	Women n=112	
Hypertension	97 (25.6)	32.4(26.4-38.4)	13.1(8.8-17.4)	< 0.001	91 (34.1)	6 (5.4)	<0.001
Subclinical atherosclerosis	40 (10.6)	13.5(9.1-17.9)	4.1(1.6-6.6)	0.006	36(13.5)	4(3.6)	0.002
Diabetes	11(2.9)	3.3(1.0-5.6)	0.4(0.1-1.2)	0.134	10(3.7)	1(0.9)	0.115
Overweight/Obesity	233 (61.5)	72.4(66.7-78.1)	53.6(47.3-59.9)	0.001	193(72.3)	40(35.7)	<0.001
Abdominal obesity	224 (59.1)	55.6(49.3-61.9)	68.6(62.7-74.5)	0.017	144(53.9)	80(71.4)	0.001
Dyslipidemia	225(59.4)	61.4(55.2-67.6)	47.1(40.7-53.5)	0.009	164(61.4)	61(54.5)	0.126
Metabolic syndrome	63(16.6)	15.5(10.9-20.1)	11.5(7.4-15.6)	0.351	43(16.1)	20(17.9)	0.39
Hyperuricemia	50(16.7)	15.6(11.0-20.2)	22.1(16.8-27.4)	0.146	39(18.2)	11(12.8)	0.166
Alcohol use	259(68.3)	51.1(46.1-56.1)	41.1(36.1-46.1)	0.075	190(71.2)	69(61.6)	0.045
Tobacco use	80(21.1)	26.1(21.7-30.5)	19.0(15.1-22.9)	0.146	69(25.8)	11(9.8)	<0.001
Physical activity	328(86.5)	11.3(7.3-15.3)	13.9(9.5-18.3)	0.559	234(87.6)	94(83.9)	0.21
Chronic kidney disease	52(13.7)	2.6(0.6-4.6)	10.0(6.2-13.8)	0.004	34(12.7)	18(16.1)	0.24
Proteinuria ≥300mg /day	29(7.7)	8.0(4.5-11.5)	13.1(8.8-17.4)	0.153	24(9.0)	5(4.5)	0.093
Fast resting heart rate	23(6.1)	7.1(3.8-10.4)	2.3(0.4-4.2)	0.075	19(7.1)	4(3.6)	0.027
Long QTc	18(4.7)	4.0(1.5-6.5)	5.9(2.9-8.9)	0.552	14(5.2)	4(3.6)	0.343
Left ventricular hypertrophy	36(9.5)	14.4(10.9-17.9)	3.0(1.3-4.7)	<0.001	32(12.0)	4(3.6)	0.006
Diastolic dysfunction	39(10.3)	13.3(9.0-17.6)	8.0(4.5-11.5)	0.159	33(12.4)	6(5.4)	0.027
High cardiovascular risk	67(17.7)	21.7(16.5-26.9)	12.9(8.6-17.2)	0.045	67(25.1)	0(0.0)	-

Values are age-adjusted and 95% confidence intervals, absolute (n) and relative (in percent) frequency

Table 4. Determinants of hypertension in univariate and multivariate analyses

Variables	Univariate analysis			Multivariate analysis		
	β	p	uOR (CI 95%)	ß	P	aOR (CI 95%)
Africans vs Caucasians	0.731	0.007	2.08 (1.23-3.52)	0.269	0.441	1.31 (0.66-2.59)
Flight crew vs Cabin crew	2.035	<0.001	7.66 (3.82-15.34)	1.601	<0.001	4.96 (2.16-11.38)
Subclinic atherosclerosis, present vs absent	1.947	<0.001	7.01 (3.48-14.12)	1.630	0.001	5.10 (1.99-13.10)
Abdominal adiposity, present vs absent	1.422	<0.001	4.15 (2.36-7.28)	0.922	0.015	2.51 (1.19-5.30)
Overweight/Obesity, present vs absent	1.971	<0.001	7.18 (3.68-14.03)	1.057	0.016	2.88 (1.22-6.77)
Elevated resting heart rate, present vs absent	1.766	0.047	5.850 (2.56-9.61)	0.961	0.049	2.62 (1.01-6.79)
Left ventricular hypertrophy, present vs absent	1.958	<0.001	7.09 (2.40-20.96)	1.590	0.02	4.90 (1.29-18.62)
LV diastolic dysfunction, present vs absent	0.802	0.029	2.23 (1.09-4.58)	0.381	0.394	1.46 (0.61-3.51)

Unadjusted OR: Odds ratio; aOR: adjusted O.R.; C.I.: Confidence interval; LV: Left ventricular