Carotid Intima-Media Thickness Correlation with Metabolic Syndrome Parameters in Military Pilots

Masud Pezeshki Rad
Mashhad University of Medical Sciences Faculty of medicine

Hamzeh Shahali
Aja University of Medical Sciences Faculty of aerospace and hyperbaric Medicine

Mahmud Momenzadeh (momenzadeh@ajaums.ac.ir)
aerospace and hyperbaric medicine https://orcid.org/0000-0002-4306-0172

Bita Yarmohammadi
Aja University of Medical Sciences, aerospace and hyperbaric medicine faculty

---

Research

Keywords: Atherosclerosis, Carotid Artery, Metabolic Syndrome, Obesity, Pilot

Posted Date: November 24th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-112895/v1

Abstract

Introduction: Metabolic syndrome is one of the important risk factors in increasing the risk of cardiovascular disease. Recent studies have shown that increasing the thickness of the intima-medial layer of the carotid artery can be a risk factor associated with metabolic syndrome.

Methods: This was a cross-sectional analytical study. All individuals underwent ultrasound of the carotid arteries. In the presence of stenosis, the stenosis caused by the plaque by North American symptomatic carotid endarterectomy trial (NASCET) was considered as a decrease in the diameter of the lumen compared to the diameter of the normal lumbar distal lobe and was expressed as a percentage. Statistical analysis of chi-square tests, independent t-test, ANOVA, and regression analysis were performed.

Results: This study was performed on 112 male pilots (average age of 41.3 years, average flight time 2435 hours). There was no statistically significant relationship between the mean thickness of intima media carotid and metabolic syndrome (no versus with metabolic syndrome: 0.62 versus 0.64 mm $p = 0.355$). The average thickness of the intima media carotid was significantly statistically different between the three groups of flight types (transport aircraft: 01.61 against fighter: 0.70 and helicopter: 0.59 mm $p = 0.004$). There is also a significant correlation between flight time and carotid thickness ($p = 0.001$, $r = 0.380$). In addition, there was a significant correlation between the age of the pilots and the thickness of the carotid artery ($p = 0.001$, $r = 0.033$) as well as the age of the pilots and the flight time ($p = 0.001$, $r = 0.713$).

Conclusion: Based on the results, there was no significant relationship between carotid thickness and metabolic syndrome and metabolic syndrome components in the studied pilots.

Introduction

Metabolic syndrome (MetS) is a combination of multiple factors including visceral obesity, hypertension, prediabetes, and atherogenic dyslipidemia[1]. Although there are still some Contradictory comments about the pathophysiologic nature of the MetS, insulin resistance is thought to be the primary cause of MetS. Studies have shown that metabolic syndrome is a risk factor for cardiovascular disease[39].

Subclinical atherosclerosis develops several years before the clinical manifestation of coronary artery disease (CAD). This process begins in early childhood and progresses into adulthood. An early manifestation of begins in early childhood the atherosclerotic process is the accumulation of lipid in the intimal layer of arteries forming fatty streaks[4], leading to morphological changes[5], a potential impact on vascular function, and eventually leading to coronary artery disease and stroke[6]. The development of atherosclerosis is accelerated in the presence of risk factors in youth, such as obesity[7–9] hypertension, dyslipidemia[10] and insulin resistance [7, 10]. If the patients are diagnosed at subclinical stages, preventive

measures can be implemented. Carotid artery stenosis, which is a common vascular disorder, is asymptomatic in many cases and increases with age.

Coronary artery angiography is the gold standard for diagnosing coronary artery disease [13]. But there are a variety of less invasive and non-invasive methods for diagnosing atherosclerosis in coronary arteries. Carotid intima media thickness (CIMT) is a well-known noninvasive independent predictor of subclinical atherosclerosis [2, 3]. In various studies, increasing the thickness of the intima media carotid artery has been identified as a useful predictive factor for coronary artery disease as well as cerebrovascular disease [14–17].

Given today's lifestyle, sedentary lifestyle, high-calorie diets, and the presence of concomitant underlying diseases, cardiovascular disease is of paramount importance. The aviation community is no exception. From an aeromedical point of view, cardiovascular disease is the leading cause of disqualification and loss of pilot certification in fighter and transport pilots [12] and CAD is a significant cause of potential in-flight incapacitation and the most common reason for permanent flying incapacitation of military pilots [40, 41]. The risk of developing coronary artery disease after age 40 is 49% in men and 32% in women in general population [11]. Accurate statistics are not available in the aviation community. Sudden cardiac death, as reported by different authors, in 20% to even 80% of military pilots has been found to be the initial presentation of CAD [40, 41]. About 75% of these cases are due to coronary artery disease, which is often detected in pilots by observing cardiac tapes without clinical signs in routine examinations [18]. In transport pilots, if the risk of sudden incapacitation is only slightly increased, the flight will continue to be licensed only with qualified pilots who do not have any problems, and in fighter pilots, any level of heart attack means that will not be allowed to fly permanently [19]. Coronary artery disease is of particular importance in aviation for the following reasons: 1) Knowing about coronary artery disease and risk factors can affect the strategy of pilot routine examinations, 2) Coronary artery disease is a common cause of pilots grounding and losing pilots' licenses, 3) The high probability of a sudden incapacitation may jeopardize safety in aviation context and finally 4) It is a disease that requires primary and secondary prevention. Because most of the risk factors for coronary artery disease (such as hypertension, obesity, etc.) can be corrected and can be reduced with timely medication and lifestyle modifications, identifying these risk factors in primary prevention is of particular importance, especially in jobs that are sensitive.

It has been shown that individual MetS components are associated with measures of carotid subclinical atherosclerosis; however, MetS is a better predictor of cardiovascular risk, possibly through higher atherosclerosis burden[42]. In this study, our goal is to examine CIMT as a predictor of cardiovascular disease and to compare its association with the components of metabolic syndrome.

Materials And Methods

This study was an analytical cross-sectional survey, it was performed on 112 pilots in 2019 and all subjects were male. Exclusion Criteria for the study included the following: clinical evidence of cardiovascular disease or clinical evidence of other atherosclerotic diseases (such as peripheral vascular disease, abdominal aortic aneurysm, and coronary artery disease), diabetes mellitus, malignancies, use of antihypertensive and lipid lowering drugs. It should be noted that all the pilots studied were active in terms of flight duties. This study was reviewed by the National Committee on Ethics in Research of the Army University of Medical Sciences of the Islamic Republic of Iran and approved with the identification of ethics.

Background information

Pilots' background information, including age, flight profile (including flight status, type of aircraft and flight hours) and the year they entered service, were collected from their files. A questionnaire including: medical and pharmaceutical records, family history of diseases and tobacco use was prepared and answered by the participants. In the case of a recent blood test (less than 3 months), including the results of a fasting blood sugar test, fat profile, and liver enzymes, the cases were extracted from the individual's annual examination file, otherwise re-examination was requested for the subjects. Measurements of height, weight, waist circumference, and blood pressure were performed on the same day of ultrasonography examination.

The steps of conducting the examinations and its general objectives were explained to the participants and the form of the informed consent of the Participate in the research plan was signed by them.

Sonography

Ultrasonography of the carotid arteries was performed when the patient was supine position and the experimenter was sitting next to the patient's head. The neck area was made as low as possible by lowering the shoulder on the same side. Ultrasonography was performed with a linear transducer with a frequency of 5.5-5 MHz. The distance between the first echogenic intima and the second echogenic related to adventitia was considered as intima media. This measurement was measured at three separate points at a distance of one centimeter in the distal wall of the common carotid arteries on both sides. The average of these three measurements on each side was considered as the thickness of the Intima Media. Atherosclerotic plaque was ultrasound detected as echogenic material that thickened the intimal reflex and penetrated into the lumen. Increasing the focal thickness of Intima Media by twice the adjacent areas was considered as a plaque. If there was a stenosis, the stenosis caused by the plaque was considered as a decrease in the diameter of the narrow lumen compared to the diameter of normal distal lumen by using North American Symptomatic Carotid Endarterectomy Trial method and was expressed as a percentage.

Data analysis

Data analysis was performed using SPSS statistical software, version 24, and for quantitative variables, the mean and standard variables were recorded, and for qualitative variables, abundance and percentage were recorded. Analytical analysis was performed with the Kai Square and Fisher and T-independent tests and logistic regression and P was considered significant less than 0.05.

Results

The results consist of two parts, descriptive statistics and inferential statistics. The study was performed on 112 pilots with an average flight time 2345.98 hours (minimum of 300 and maximum of 14,000 hours). The type of aircraft was an 82-transport aircraft, 18 fighter jet and 12 helicopters. The mean age of the subjects was 41/33 years. The oldest person in the study was 65 years old and the youngest was 29 years old. Most of the subjects in the study age range were 35 to less than 45 years. 22 pilots (19.6%) were given positive history of smoking. The average height of the participants in the study was177.7 cm, the tallest person was 189 cm and the shortest was 165 cm. Average weight of participants was 83 kg (65 kg minimum, 127 kg maximum) and average body mass index (BMI)26.3 kg/m2 (maximum 41.5 cm2 and minimum 20.1 kg/m2) were obtained. Also, the mean waist circumference in the subjects under study was 95.4 cm (130 cm maximum and 79 cm minimum).

The mean systolic and diastolic blood pressures were 113.1-and 70.9-mm Hg, respectively. The maximum systolic and diastolic blood pressure obtained was 130- and 85-mm Hg, and the minimum systolic and diastolic blood pressure was 90- and 60-mm Hg. The mean serum fasting blood sugar level among the subjects was 91.1 mg/dl. The maximum fasting blood sugar in the people studied is 112 and the minimum is 74 mg/dl recorded. In 3 patients (67.2%), fasting blood sugar was more than or equal to 110 mg/dl.

Average serum levels reported for total cholesterol (173.5 mg / dL, maximum 271 and minimum 98) and for triglycerides (43.7 mg/dL, minimum 43 and maximum 294). Also, the mean serum level of LDL 91.6 mg/dl (minimum 45 and maximum 146) was and HDL was 44.1 mg/dl (minimum 26 and maximum73). An examination of the status of liver enzymes showed an average serum level of ALT 29.8 IU/L the mean serum level of AST was 25.1 IU/L and alkaline phosphatase was 170.6 IU/L. In all participants, serum levels of liver enzymes were in normal range. All information is given in Table 1.

Table 1
study subjects risk factors for atherosclerosis

Variable	Mean ± SD
Age (yr)	41.33 ± 6.80
Height(cm)	177/7 ± 8.45
Weight (kg)	83 ± 4.034
Body mass index (kg /m^2)	26/3 ± 3.65
Waist circumference (cm)	95.4 ± 7.77
Systolic blood pressure (mmHg)	113.1 ± 8.77
Diastolic blood pressure (mmHg)	70.94 ± 7.48
Total cholesterol (mmol z L21)	173/5 ± 9.87
HDL-c (mmol / L)	44.12 ± 7.35
LDL-c(mmol /L)	91/6 ± 7.023
Tg (mmol/ L)	139.8 ± 46.11
Fasting glucose (mmol / L)	91.10 ± 9.23
Smoking habits:Yes (%)/No (%)	22 (19.6), 90(80.4)

The prevalence of metabolic syndrome in the subjects under our study was 8% (9 participants). Of these, 4 had four components of metabolic syndrome and 5 had three components.

Ultrasound Findings

The mean Carotid Intima Media thickness was 0.6 on the right and 0.65 mm on the left. Also, the total Carotid Intima Media thickness (average thickness of Intima Media Carotid right and left) was calculated to be 0.625 mm. Measurements above normal (> 0.8 mm) of left carotid artery were measured in 16 subjects and for right carotid artery in 9 subjects. In 3 people, the thickness was higher than normal on both sides. Carotid plaque was observed in 5 patients (4.4%). In 3 patients, there was a left isolation plaque and in one patient there was a right isolation plaque. One patient had a plaque on both side. None of these individuals were in the metabolic syndrome group. In one patient (0.9%), some degree of carotid stenosis was observed. In this patient, there was simultaneous right (less than 30%) and left (more than 30%) carotid stenosis.

Comparison of mean intima-mediated thickness of right and left carotid arteries in people with or without metabolic syndrome showed no significant statistical relationship between thickness values and

metabolic syndrome. The relationship between the CIMT and the components of the metabolic syndrome is shown in Table 2.

Table 2
CIMT and the components of the metabolic syndrome

Variable	Carotid intima- media thickness	P-value
Metabolic syndrome present (n = 9)	64%	0.535
Metabolic syndrome absent(n = 103)	62%	
Waist circumference (Nl)	62%	0.068
Waist circumference (> 102 cm)	74%	
Tg (mmol/ L) (NL)	61%	0.374
Tg (mmol/ L) (> 150 mg/dl)	63%	
HDL-c (mmol / L) (NL)	62%	0.827
HDL-c (mmol / L) (< 40 mg/dl)	63%	
Fasting glucose (mmol / L) (NL)	63%	0.566
Fasting glucose (mmol / L) (≥ 110 mg/dl)	58%	
Blood pressure (mmHg) (NL)	62%	0.571
Blood pressure (mmHg) (≥ 130/80)	63%	

Pearson correlation analysis showed that there was a significant correlation between flight time and carotid thickness (P = 0.001, r = 0.380). In addition, there was a significant correlation between the increase in the age of the pilots and the thickness of the carotid (P = 0.001, r = 0.033), as well as the age of the pilots and the flight time (P = 0.001, r = 0.713).

Discussion

Cardiovascular disease (CVD) was ranked as the leading global cause of death in 1990 and 2010. The global death rate associated with CVD for individuals aged 15 to 49 was 10.7% in female patients and 12.8% in male patients in 2010 [20]. Fortunately, cardiovascular disease (CVD) is a relatively infrequent cause of sudden incapacitation in aircrew, but it accounts for 50% of all pilot licences declined or withdrawn for medical reasons in Western Europe [21–23]. Aircrew is medically screened more intensively than many other professions; however, despite this, cardiovascular conditions such as acute coronary syndromes remain a causative factor in commercial aircraft accidents and fatalities [24, 25].

The metabolic syndrome is one of the major public health problems worldwide [29], the prevalence of MetS are continuously increasing and aircrews are not spared from this high prevalence. Military and civilian

aircrew is held to stringent physical standards in order to be considered qualified for flight. While MetS itself can be a medical condition which causes flight disqualification if it's associated with another cardiovascular disease like hypertension, diabetes, coronary disease or sleep apnea syndrome. The presence of the MetS is associated with a significant increase in cardiovascular mortality (12% vs. 2%) [30] and all-cause of mortality[31]. it's also associated with a high risk of cardiovascular disease (CVD). In flight MetS can cause sudden or subtle incapacitation by the occurrence of acute myocardial infarction, stroke or by a sudden death[32]. These complications can be decompensated by altitude and flight conditions including altitude hypoxia, stress and + Gz acceleration in fighter pilot in a high-performance aircraft. Non-diabetic people with the MetS are at a very high risk for developing type 2 diabetes, the risk for diabetes is up to fivefold higher in patients with the syndrome[31] In aircrew member, diabetes may have an impact on the flight safety through its complications (ocular, cardiovascular, stroke, etc.), and through the glycemic disorder which may cause hypoglycemia in flight[33]. Obesity is rising rapidly in many parts of the world[34], and the high prevalence of the MetS is mainly related to the obesity epidemic[35].

The aim of this study was to investigate the intima media thickness of the carotid artery and compare with the criteria of metabolic syndrome in pilots. The main results included a lack of association between increased carotid intima media thickness and metabolic syndrome and metabolic syndrome components, a higher carotid thickness in fighter pilots, and a correlation between carotid intima media thickness and age and flight time.

In our study, no significant statistical or clinical association was found between CIMT and metabolic syndrome and its components, perhaps most importantly due to the low number of people in the metabolic syndrome group and the consequent low prevalence of metabolic syndrome in the pilot population. In our study, the prevalence of metabolic syndrome was 8%, which is much lower than the reported global values, the Middle East region and the Iranian population in the general population. Currently, the global prevalence and prevalence in the Middle East is estimated at about 25%[26]. This rate is reported to be 29% for men in Iran[27]. Other studies show that the prevalence of metabolic syndrome in the group of pilots of the Jordanian Air Force is 18%, the Korean Air Force is 9.9%, the Taiwan Air Force is 5.32%, the German Air Force is 9.0%, the Serbian Air Force is 5.28% and the US Air Force Less than 1% [28], which shows a lower prevalence of the syndrome in countries that have stricter protocols in their pilots' health.

However, the results of this study showed that none of the known risk factors, despite having a relatively high prevalence in the subjects, were not significantly associated with the thickness of the carotid artery. This was confirmed both in intergroup analyzes using chi-square and t-test analyzes and in regression models. However, the findings of our study are different from the findings of a single study that was similar in design to our study.

In addition, due to the proven link between high blood pressure, dyslipidemia and high body mass index with coronary syndromes, cardiac arrhythmias, and heart attack, and the high prevalence of these risk

factors, individually in the subjects studied, Precautions must be taken to ensure that pilots are closely monitored[36]. Although a person is not diagnosed with one or two positive criteria as metabolic syndrome, with age, the risk of metabolic syndrome, cardiovascular disease, and diabetes will be higher than in people without symptoms.

High blood pressure, diabetes mellitus, smoking, dyslipidemia, old age, as well as metabolic syndrome have been identified as common risk factors for atherosclerosis of the carotid and cardiac arteries. Although the possible underlying mechanisms of the causes of metabolic syndrome and carotid damage are not yet well understood and are not the subject of this study, some studies have shown that all metabolic components of the syndrome alone can accelerate vascular endothelial disorders and, as a result, progressive arterial damage, and increase the chances of developing carotid disorders as the number of metabolic syndrome components increases[37].

Although the diagnosis of metabolic syndrome does not in itself cause the pilot to be disqualified, some of its components, such as hyperglycemia, hypertension, and fat profile disorder, can cause at least a temporary loss of a pilot's license. This is important in the sense that in our study, about 60% of pilots were overweight, more than 40% had triglyceride abnormalities, and about 20% smoked, once again demonstrates the importance of controlling and minimizing risk factors in order to reduce the risk of vascular disorders[38].

The study was accompanied by limitations. This study was conducted cross-sectionally in one center, so there were all the limitations of cross-sectional studies, such as the inability to fully control distorting interventions in this study. Due to the time allotted for the project, it was not possible to examine more people, so it is recommended that the project be continued in a larger population of pilots and in multiple centers.

Conclusion

Based on the results, no significant relationship was found between carotid thickness and metabolic syndrome and the components of metabolic syndrome in the Iranian pilots studied. The study found that the thickness of the carotid artery in fighter pilots was significantly increased compared to the commercial pilots. Also, a significant correlation was shown between carotid thickness with age and flight time. Given the relatively high prevalence of metabolic syndrome in the population of Iranian pilots (about 8%) compared to other countries, it seems that more preventive strategies should be considered to control the risk of cardiovascular factors.

Abbreviations

MetS
Metabolic syndrome
CAD

coronary artery disease
CVD
Cardiovascular disease
CIMT
Carotid intima media thickness
BMI
body mass index

Declarations

Ethics approval and consent to participate

To do this research, we obtained the necessary permits from the ethics committee of AJA University of Medical Sciences. Consent was obtained from the participants to participate in the study, and each of the participants at any stage of the study could leave the study if they wished.

Consent for publication

We, the authors of the article, express our consent to the publication of the article.

Availability of data and materials

All study data are available.

Competing interests

Not applicable

Funding

Not applicable

Authors' contributions

All authors played an active role in reading and compiling the article.

Acknowledgments

We thank all colleagues and all of the study participants, who willingly gave their time for this study.

References

1. Grundy SM, Brewer Jr HB, Cleeman JI, Smith Jr SC, Lenfant C, National Heart, Lung, and Blood Institute; American Heart Association. Definition of metabolic syndrome: report of the National Heart,

Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. Arterioscler Thromb Vasc Biol 2004;24: e13–8

2. Carpenter M, Sinclair H, Kunadian V. Carotid intima media thickness and its utility as a predictor of cardiovascular disease: a review of evidence. Cardiol Rev 2016; 24:70–5.
3. Naqvi TZ, Lee MS. Carotid intima-media thickness and plaque in cardiovascular risk assessment. JACC Cardiovasc Imaging 2014; 7:1025–38.
4. McGill HC, Jr. The pathogenesis of atherosclerosis. Clin Chem 1988;34: B33–B39.
5. Ross R. Atherosclerosis is an inflammatory disease. Am Heart J 1999;138: S419–S420.
6. Libby P. Inflammation in atherosclerosis. Nature 2002;420: 868–874.
7. Raghuveer G. Lifetime cardiovascular risk of childhood obesity. Am J Clin Nutr 2010; 91:1514S–1519S.
8. Freedman DS, Patel DA, Srinivasan SR, et al. The contribution of childhood obesity to adult carotid intima-media thickness: The Bogalusa Heart Study. Int J Obes (Lond) 2008; 32:749–756.
9. Berenson GS, Srinivasan SR, Bao W, et al. Association between multiple cardiovascular risk factors and atherosclerosis in children and young adults. The Bogalusa Heart Study. N Engl J Med 1998; 338:1650–1656.
10. Le J, Zhang D, Menees S, et al. “Vascular age” is advanced in children with atherosclerosis-promoting risk factors. Circ Cardiovasc Imaging 2010; 3:8–14.
11. Jameson, J. Larry. 2019. Harrison’s Manual of Medicine
12. Gradwell, David P, and David J Rainford. 2016. aviation and space medicine ernsting ’ s fifth edition.
13. Lim MJ, White CJ. Coronary angiography is the gold standard for patients with significant left ventricular dysfunction. Prog Cardiovasc Dis.2013 Mar-Apr;55(5):504-8.
14. Jinzy Mariam George, Raghavendra Bhat, Mohan Pai, Arun S., and Jayakumar Jeganathan. The Carotid Intima Media Thickness: A Predictor of the Clincal Coronary Events. J Clin Diagn Res.2013 Jun; 7(6): 1082–1085.
15. Phan, Thanh G, Richard J Beare, Damien Jolley, Gita Das, Mandy Ren, Kitty Wong, Winston Chong, Matthew D Sinnott, James E Hilton, and Velandai Srikanth. 2012. “Carotid Artery Anatomy and Geometry as Risk Factors for Carotid Atherosclerotic Disease.” Stroke 43 (6): 1596–1601.
16. Sirous Darabian,1 Mehera Hormuz,1 Muhammad Aamir Latif,1 Sogol Pahlevan,2 and Matthew J. Budoff1,3 The Role of Carotid Intimal Thickness Testing and Risk Prediction for the Development of Coronary Atherosclerosis. Curr Atheroscler Rep. 2013 Mar; 15(3): 306. doi: 1007/s11883-012-0306-4
17. Yiyi Zhang, Eliseo Guallar, Ye Qiao, and Bruce A. Wasserman. Is Carotid Intima-Media Thickness as Predictive as Other Noninvasive Techniques for the Detection of Coronary Artery Disease? Arteriosclerosis, Thrombosis, and Vascular Biology.2014;34:1341–1345
18. Eddie D Davenport, Gary Gray, Rienk Rienks, Dennis Bron, Thomas Syburra, Joanna L d’Arcy, Norbert J Guettler, Olivier Manen, and Edward D Nicol. Management of established coronary artery disease in aircrew without myocardial infarction or revascularization. Heart.2019 Jan;105(Suppl 1): s25–s30.

19. International Civil Aviation Organization (ICAO). 2012. Doc 8984 Manual of Civil Aviation Medicine.
20. Lozano R, Naghavi M, Foreman K, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet, 2012; 380, 2095–128.
21. Joy M Cardiological aspects of aviation safety. Eur Heart J 1999; 20:481–3.
22. Joint Aviation Authorities JAA. Manual of civil aviation medicine. 2009
23. International Civil Aviation Organization ICAO. Manual of Civil Aviation Medicine, Part I Licensing Practices - Preliminary Edition, 2008.
24. DeJohn CA , Wolbrink AM , Larcher JG . In-flight medical incapacitation and impairment of U.S. airline pilots: 1993 to 1998. Washington, DC: Federal Aviation Administration, Office of Aerospace Medicine, 2004. Tech Rep No DOT/FAA/AM-04/16.
25. DeJohn CA , Wolbrink AM , Larcher JG. In-flight medical incapacitation and impairment of U.S. airline pilots: 1993 to 1998. Washington, DC: Federal Aviation Administration, Office of Aerospace Medicine, 2004. Tech Rep No DOT/FAA/AM-04/16.
26. Saklayen, Mohammad G. 2018. “The Global Epidemic of the Metabolic Syndrome.” Current Hypertension Reports 20 (2): 12.
27. Dalvand, Sahar, Seyed Hassan Niksima, Reza Meshkani, Reza Ghanei Gheshlagh, Sahar Sadegh-Nejadi, Wesam Kooti, Naser Parizad, Hossein Zahednezhad, and Reza Afrisham. 2017. “Prevalence of Metabolic Syndrome among Iranian Population: A Systematic Review and Meta-Analysis.” Iranian Journal of Public Health 46 (4): 456–67. http://www.ncbi.nlm.nih.gov/pubmed/28540261
28. Khazale, N S, and F Haddad. 2007. “Prevalence and Characteristics of Metabolic Syndrome in 111 Royal Jordanian Air Force Pilots.” Aviat Space Environ Med 78 (10): 968–72.
29. Zimmet P, Magliano D, Matsuzawa Y, et al. The metabolic syndrome: a global public health problem and a new definition. J Atheroscler Thromb.2005;12(6):295–300.
30. Isomaa B, AlmgrenP, Tuomi T, et al. Cardiovascular Morbidity and Mortality Associated with the Metabolic Syndrome. Diabetes Care. 2001;24(4):683–689.
31. Stern MP, Williams K, González–Villalpando C, et al. Does the metabolic syndrome improve identification of individuals at risk of type 2 diabetes and/or cardiovascular disease? Diabetes Care. 2004;27(11):2676–2681.
32. Brocq FX, Deroche J, Chemsi M, et al. Management of metabolic syndrome by the aeromedical examiner. Med Aero Spat. 2009; 50:19–25.
33. Deroche J, Paris JF, Perrier E, et al. Management of a diabetes mellitus in the private pilot fitness assessment. Med Aero Spat. 2004; 45:6–10
34. Visscher TL, Seidell JC. The public health impact of obesity. Annu Rev Public Health. 2001; 22:355–375.
35. Saad MF, Lillioja S, Nyomba BL, et al. Racial Differences in the Relation between Blood Pressure and Insulin Resistance. N Engl J Med. 1991;324(11):733–739.

36. Shamloo, Alireza Sepehri, Nikolaos Dagres, Arash Arya, and Gerhard Hindricks. 2018. “Atrial Fibrillation: A Review of Modifiable Risk Factors and Preventive Strategies.” Romanian Journal of Internal Medicine.
37. Cuspidi, C, C Sala, F Provenzano, M Tadic, E Gherbesi, G Grassi, and G Mancia. 2018. “Metabolic Syndrome and Subclinical Carotid Damage: A Meta-Analysis from Population-Based Studies.” J Hypertens 36 (1): 23–30. https://doi.org/10.1097/HJH.0000000000001575.
38. Sherling, D H, P Perumareddi, and C H Hennekens. 2017. “Metabolic Syndrome.” J Cardiovasc Pharmacol Ther 22 (4): 365–67. https://doi.org/10.1177/1074248416686187.
39. Mojgan Jalalzadeh, Nouraddin Mousavinasab, Mehrdad Soloki, Reza Miri, Mohammad Hassan Ghadiani, and Maryam Hadizadeh, Association Between Metabolic Syndrome and Coronary Heart Disease in Patients on Hemodialysis. Nephrourol Mon. 2015 Jan; 7(1): e25560.
40. McCrary BF, Van Syoc DL. Permanent fl ying disqualifi cations of USAF pilots and navigators (1995-1999). Aviat Space Environ Med 2002 ; 73 :1117 – 21 .
41. Osswald S, Miles R, Nixon W, Celio P. Review of cardiac events in USAF aviators. Aviat Space Environ Med 1996 ; 67: 1023 – 7.
42. Tzou SW, Douglas SP, Srinivasan RS, Bond MG, Tang R, et al. Increased subclinical atherosclerosis in young adults with metabolic syndrome: the Bogalusa Heart Study. J Am Coll Cardiol 2005 ; 46 : 457 –