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Prevalence of hepatic steatosis and fibrosis in apparently healthy airline pilots: A transient elastography study

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Abstract

Background and Aim: Airline pilots (APs) are often characterized by a sedentary lifestyle, predisposing them to adverse cardiometabolic consequences. In this cross-sectional study, we used transient elastography (TE) to investigate the prevalence of hepatic steatosis and fibrosis among apparently healthy APs.

Materials and Methods: The study cohort consisted of 137 male APs of Caucasian descent who voluntarily underwent TE. To evaluate the extent and severity of hepatic steatosis and fibrosis, we employed established cut-off values for the controlled attenuation parameter (CAP) and liver stiffness measurement (LSM).

Results: Of the APs, 34 (24.8%) were diagnosed with TE-defined steatosis. Specifically, 25 APs (18.2%) exhibited mild steatosis, 6 (4.4%) moderate steatosis, and 3 (2.2%) severe steatosis. The majority of participants (80 APs or 58.4%) showed no signs of liver fibrosis based on LSM values. However, 49 APs (35.8%) were diagnosed with mild fibrosis (F1), 7 (5.1%) with significant fibrosis (F2), and one (0.7%) with advanced fibrosis (F3). None of the pilots had F4 (cirrhosis). In multivariable linear regression analysis, BMI was the sole independent predictor of both CAP ($\beta=0.34$, $p<0.001$) and LSM ($\beta=0.41$, $p<0.001$) values in our sample of male APs.

Conclusion: TE is a straightforward and convenient non-invasive method for detecting hepatic steatosis and fibrosis in high-risk occupational groups such as APs.

Keywords: Airline pilots; fibrosis; hepatic steatosis; screening; transient elastography.

Introduction

Airline pilots (APs) tend to exhibit a sedentary lifestyle while performing their flight responsibilities.[1] Additionally, their generally unhealthy eating habits, influenced by irregular meal times intermixed with their work schedule, could potentially result in an array of unfavorable cardiometabolic outcomes.[2] A seminal study found that metabolic syndrome (MS), as defined by the National Cholesterol Education Program, Adult Treatment Panel III, affects 14.8% of APs.[3] A more recent analysis of 304 male APs revealed that 53.6% were overweight, 6.4% were classified as obese, 64.3% had significantly high relative adiposity, and 64.6% showed abdominal obesity.[1] Importantly, certain occupational factors inherent to airline piloting – including fatigue, irregular work schedules, sleep disruptions, shift work, and psychological stress – may exert detrimental effects on metabolic health.[4]

Non-alcoholic fatty liver disease (NAFLD) is characterized by the accumulation of fat in hepatocytes, exceeding 5% of liver weight, in individuals without a history of significant alcohol consumption.[5] While the most suitable terminology for steatotic liver diseases is a topic of ongoing debate, with a growing movement to replace NAFLD with novel terms like metabolic (dysfunction) associated fatty liver disease (MAFLD) or metabolic dysfunction-associated steatotic liver disease (MASLD),[6,7] the acronym NAFLD is still commonly used, especially in the screening setting. Although liver ultrasound remains the most widely used imaging technique for detecting NAFLD in apparently healthy individuals, it can only identify hepatic steatosis if the liver fat content exceeds 30%.[8] To address this limitation, transient elastography (TE; FibroScan®, Echosens SA, Paris, France) has emerged as a robust imaging technique that can effectively identify both fibrosis and steatosis without the need for invasive procedures.[9] TE works by measuring the velocity of low-frequency elastic shear waves passing through the liver.[10] This velocity is directly proportional to tissue stiffness, represented in kiloPascals (kPa). A healthy liver stiffness measurement (LSM) – a key imaging biomarker for hepatic fibrosis – ranges from 2.5 to 7.5 kPa, with the average estimate being around 5.5 kPa.[11] TE also has the capacity to evaluate hepatic steatosis using the controlled attenuation parameter (CAP).[8] CAP gauges the attenuation of ultrasonic wave signals through the liver, simultaneously captured with LSM by the TE probe. CAP is quantified in decibels per meter (dB/m), with typical values falling between 100 to 400 dB/m. Higher CAP values signify a greater degree of hepatic fat accumulation. Importantly, CAP measurements can identify milder grades of steatosis compared to conventional ultrasound.[8] Research by Sasso et al.[12] established a CAP cut-off value of 238 dB/m, showing a 91% sensitivity and 81% specificity for detecting at least 10% steatosis. Intriguingly, a study by Yilmaz et al.[13] showed that, when applying this particular cut-off point, a substantial 22.5% of subjects who initially presented normal liver ultrasound results demonstrated TE-established steatosis. In a separate

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study conducted by the same research group, a significant 23.2% of seemingly healthy Turkish students showed evidence of NAFLD based on measured CAP values.[8]

To our knowledge, there have been no previous studies on the prevalence of TE-identified hepatic steatosis and fibrosis among apparently healthy APs, a professional group known to be at risk for impaired metabolic health.[1–4] Therefore, we conducted a cross-sectional investigation to fill this knowledge gap and identify the risk factors associated with NAFLD as detected by TE.

Materials and Methods

Participants

The study involved a convenience sample of 151 male APs of Caucasian descent who willingly underwent TE for LSM and CAP quantification. These pilots were recruited during their routine occupational health visits at outpatient clinics, where they received an invitation from an occupational health physician. Owing to the limited number of female pilots, they were not included in this study. All APs, who were apparently healthy, denied any significant alcohol consumption, defined as more than 30 grams per day. The exclusion criteria incorporated individuals with endocrine disorders (including type 2 diabetes mellitus), psychiatric or neurological conditions, autoimmune diseases, malignancies, or infectious diseases (including viral hepatitis). Additionally, participants who had been taking dietary supplements or had a history of medication use in the 90 days leading up to the TE measurements were deemed ineligible. Anthropometric measurements, encompassing body mass index (BMI), waist circumference, and hip circumference, were gathered from all APs. The study protocol received approval from the local ethics committee (reference number: 2021/FI_TU). Prior to the commencement of data collection, written informed consent was obtained from all participants.

Transient Elastography

We performed TE examinations using the FibroScan® 502 touch device (Echosens SA) as per the manufacturer's instructions. In brief, LSM assessments were conducted using the M probe at a consistent location in the right lobe of the liver, while the subject was positioned in the dorsal decubitus position with the right arm in maximal abduction. No participant required the use of the XL probe. Once the measurement area was accurately identified, the acquisition commenced, targeting a depth range of 25 to 65 mm. None of the APs had any intra-cardiac devices or physical disabilities that could have hindered the examination process. If a valid LSM record was not obtained after 10 attempts, the LSM was deemed unsuccessful and subsequently excluded. We applied the reliability criteria established by Boursier et al.[14] As such, LSM with an interquartile range/median LSM greater than 0.3 kPa, along with a median LSM equal to or exceeding 7.1 kPa, were deemed insufficiently reliable and were therefore excluded. A total of 14 participants were excluded due to unreliable measurements. Therefore, the final study cohort consisted of 137 APs.

Stages of Steatosis and Fibrosis

The median CAP score cut-off values for various steatosis grades (S0–S3) were established based on a meta-analysis on CAP technology.[15] Steatosis grade S0 (i.e., less than 10% steatosis) was denoted by a CAP of less than 248 dB/m. Mild steatosis (grade S1) was characterized by a CAP ranging from 248 to less than 268 dB/m, indicative of 10% to less than 33% steatosis. Moderate steatosis (grade S2) corresponded to a CAP score from 268 to less than 280 dB/m, representing 33% to less than 66% steatosis. Finally, severe steatosis (grade S3) was defined by a score of 280 dB/m or higher, signifying 66% or more steatosis.[15] The classification of median LSM cut-off values for hepatic fibrosis was in accordance with the study by Nastasa et al.,[16] as follows: F0 (no fibrosis) for values less than or equal to 5.5 kPa; F1 (mild fibrosis) for values between 5.6 and 7.1 kPa; F2 (significant fibrosis) for values in the range of 7.2 and 9.4 kPa; F3 (advanced fibrosis) for values from 9.5 to 12.4 kPa; and F4 (cirrhosis) for values greater than or equal to 12.5 kPa.[16]

Table 1. General characteristics and transient elastography findings in the 137 airline pilots who entered the final analysis

	Airline pilots (n=137)
Age (years)	40.3±4.5
Body mass index (kg/m^2)	24.2±3.2
Waist circumference (cm)	81.2±10.8
Hip circumference (cm)	102.7±8.6
Non-overweight, n (%)	101 (73.7)
Overweight, n (%)	36 (26.3)
Obese, n (%)	0 (0)
Liver steatosis, n (%)	34 (24.8)
Steatosis degree, n (%)	
0	103 (75.2)
1	25 (18.2)
2	6 (4.4)
3	3 (2.2)
Fibrosis stage, n (%)	
0	80 (58.4)
1	49 (35.8)
2	7 (5.1)
3	1 (0.7)
CAP, dB/m	231.2±44.6
LSM, kPa	5.4±1.3

CAP: Controlled attenuation parameter; LSM: Liver stiffness measurement.

Statistical Analysis

Continuous data are expressed as mean±standard deviations, whereas categorical variables are presented as counts and percentages. Multivariable stepwise linear regression analyses were implemented to identify the independent predictors of CAP and LSM. We entered age, BMI, waist circumference, and hip circumference into the final multivariable model as potential predictors/covariates. Analyses were carried out using SPSS, version 20.0 (IBM, Armonk, NY, USA), and two-tailed $p<0.05$ were considered statistically significant.

Results

Table 1 shows the general characteristics and TE parameters of the 137 APs included in the study. Initially, we gauged the incidence of hepatic steatosis by utilizing the previously identified optimal CAP cut-off point of 238 dB/m. Out of the total, 34 APs (24.8%) were diagnosed with TE-defined NAFLD. In detail, 25 APs (18.2%) manifested mild steatosis, 6 APs (4.4%) exhibited moderate steatosis, and 3 APs (2.2%) showed severe steatosis. The majority of the study participants (80 APs or 58.4%) displayed no signs of liver fibrosis based on LSM values. However, 49 APs (35.8%) were diagnosed with mild fibrosis (F1), 7 APs (5.1%) with significant fibrosis (F2), and one AP (0.7%) with advanced fibrosis (F3). None of the pilots were found to have F4 (cirrhosis). In the multivariable linear regression analysis, BMI was identified as the sole independent predictor of both CAP (β=0.34, $p<0.001$) and LSM (β=0.41, $p<0.001$) values in our sample of male APs.

Discussion

NAFLD commonly remains asymptomatic until it progresses to advanced stages, emphasizing the critical importance of implementing screening procedures that can detect this condition in its early phases, even among seemingly healthy individuals.[8,16] TE has proven to be an efficient, non-invasive, and consistent method for assessing liver steatosis and fibrosis across various high-risk groups.[17–20] This is, to our knowledge, the first study that specifically examines the prevalence of TE-confirmed hepatic steatosis and fibrosis in male APs. Our findings show that around 25% of the pilots, who appeared healthy, exhibited steatosis, while approximately 6% had F2 fibrosis or worse. As anticipated, BMI – even without obesity – was identified as the main independent predictor of steatotic and fibrotic liver alterations. The prevalence of TE-defined steatosis observed in our APs (24.8%) aligns with similar findings in other apparently healthy populations, such as Turkish medical students (23.2%),[8] Romanian medical students (17.4%),[16] and British apparently healthy young adults (20.7%).[21] Our findings align with studies conducted in the general population, which have identified BMI as a strong predictor of hepatic steatosis.[8]

While steatotic liver infiltration is the hallmark of NAFLD, liver fibrosis has consistently emerged as the primary predictor of adverse hepatic and extrahepatic outcomes.[22] In our study, the majority of participants exhibited no or mild liver fibrosis, while 6% showed significant or advanced fibrosis. These results are consistent with previous research in the general population. A Korean study conducted by You et al.[23] found a similar prevalence of significant fibrosis (6.9%) among apparently healthy subjects, which aligns with our findings. Two published studies also reported a prevalence of significant liver fibrosis ranging from 5.6% to 7.5% in the general population without known chronic liver disease.[24,25] This suggests that a significant number of seemingly healthy APs are at high risk of developing chronic liver disease. Furthermore, we observed that LSM, like CAP, maintained an independent association with BMI.[16] The findings of our study indicate the need for personalized screening strategies for hepatic steatosis and fibrosis in pilots, taking into account their BMI values, even if they do not meet the criteria for obesity. Pilots in this subgroup could benefit from non-pharmacological interventions, such as adopting a healthier lifestyle with regular physical exercise and improved dietary habits, to reduce the risk of progressive liver disease.

While our study has significant implications for occupational health and the prevention of NAFLD in pilots, it is important to consider several limitations when interpreting our findings. Firstly, due to ethical reasons, APs with TE-identified hepatic steatosis and fibrosis did not undergo diagnostic confirmation through liver biopsies. Secondly, our pilots did not undergo liver ultrasound. The current study was not designed to compare the accuracy of TE for NAFLD screening with other imaging modalities. Although ultrasound is less expensive, it is also less sensitive.[8] Interestingly, a previous report suggested that hepatic steatosis could serve as a reliable marker of MS and could be non-invasively screened in aviators using abdominal ultrasound.[26] The authors concluded that liver steatosis could play a crucial role in identifying aviators who require further cardiovascular evaluation and guiding lifestyle modifications.[26] In the future, a rigorous cost-effectiveness analysis comparing these two techniques should be conducted. Thirdly, due to the specific focus of our research project on APs volunteering for TE, we lacked data on lipid parameters and serum aminotransferases, which are necessary for diagnosing MS. Furthermore, our results are derived from a single measurement of LSM and CAP. Future investigations should consider relying on repeated or serial measurements of these parameters to ensure more robust findings. Finally, we acknowledge the unique health challenges that military pilots encounter.[27] We believe it will be crucial to delve deeper into the possible differences in TE parameters between commercial and military APs, warranting additional investigation in future research.

Conclusion

Despite these limitations, our study demonstrates that TE is a straightforward and convenient non-invasive method for detecting hepatic steatosis and fibrosis in high-risk occupational groups such as APs. This is especially significant as it allows for the early detection of NAFLD in seemingly healthy pilots, enabling timely intervention through evidence-based interventions targeting nutrition, physical activity, and sleep hygiene.[28] Considering the critical role APs play in ensuring the safety of millions of travelers globally,[4] it is imperative to prioritize providing guidance and support to overweight pilots. Furthermore, prospective studies are needed to further evaluate the usefulness of LSM and CAP as imaging biomarkers for predicting clinical cardiometabolic outcomes in this occupational group.

Ethics Committee Approval: The study protocol received approval from the local ethics committee (reference number: 2021/FI_TU).

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