The prevalence and distribution of health risk factors in airline pilots: a cross-sectional comparison with the general population

Daniel Wilson,[1,2] Matthew Driller,[3] Ben Johnston,[4] Nicholas Gill[1,5]

Abstract

Objective: To explore the prevalence and distribution of health risk factors in airline pilots and compare these with the general population.

Methods: Health risk measures: age, sex, weight, height, body mass index (BMI), blood pressure, sleep, physical activity (PA) and fruit and vegetable intake (FV) were analysed to determine the prevalence and distribution of health risk.

Results: Obesity prevalence and BMI was lower in pilots ($p=<0.001$, -17.5%, $d=-0.41$, and $p=<0.05$, -1.8, $d=-0.37$, respectively), yet overall overweight and obesity prevalence did not differ between groups ($p=0.20$). No difference was observed between groups for hypertension ($p=0.79$, $h=-0.01$), yet a higher proportion of pilots were 'at risk' for hypertension ($p=<0.001$, $h=-0.34$). The general population had longer sleep duration ($p=<0.001$, $d=0.12$), achieved more total PA minutes ($p=<0.001$, $d=0.75$), and had a higher prevalence of positive self-rated health ($p=<0.001$, $h=0.31$). More pilots achieved >5 servings of FV daily ($p=0.002$, $h=0.16$).

Conclusion: Pilots had lower obesity prevalence, higher FV, yet lower positive self-health ratings and total PA minutes, and shorter sleep duration overall.

Implications for public health: The results indicate notable health risk factor prevalence in airline pilots and the general population. Based on present findings, aviation health researchers should further examine targeted, cost-effective intervention methods for promoting healthy bodyweight, managing blood pressure, and enhancing health behaviours to mitigate the risks of occupational morbidity, medical conditions causing loss of licence, medical incapacity, and to support flight safety.

Key words: morbidity, non-communicable disease risk, health behaviour, overweight and obesity, hypertension, occupational health, diet, physical activity, sleep, subjective health

Generally, pilots are considered to have better health status than the general population,[1,2] however, work characteristics of professional airline pilots may present unique risks which may negatively impact health.[3-6] Pilots are subject to circadian disruption from shift work and irregular flight schedules, perceived fatigue, cosmic ionizing radiation exposure, irregular mealtimes, mental stress demands associated with flight safety, the sedentary nature of the job, and noise, vibration and air quality of the cabin environment.[1,3,7,8] Some evidence has indicated an elevated incidence for melanoma and kidney disease compared to the general population.[1,4] Further, noteworthy risk prevalence has been reported for back pain,[9] obesity,[2,5] metabolic syndrome,[10] physical inactivity,[8,11] poor sleep,[11,12] and depressive symptoms in pilots.[13]

In contrast, protective factors associated with being an airline pilot, such as socioeconomic status, the healthy worker effect and being subject to regular medical examinations, are thought to mitigate some health risks.[1,2] Indeed, based on some previous investigations,[1,2] pilots are generally considered to have a lower prevalence of non-communicable diseases (NCDs) and a lower risk for most health conditions than the general population. However, to date, there is a limited literature base pertaining to the quantification of behavioural risk factors in airline pilots and the distribution of health risk factors among different age groups.

Non-communicable diseases such as cardiovascular disease, cancer, chronic respiratory diseases and diabetes are the leading cause of mortality worldwide,[14] highlighting the importance of community integration of measures to counteract NCDs. With global strategic targets to reduce premature deaths from NCDs,[14] surveillance and quantification of health risks associated with NCD pathogenesis are vital to inform health initiatives to prevent, manage or treat NCDs.

The global obesity prevalence nearly doubled from 7% in 1980 to 13% in 2015.[15] Obesity is a complex, multifactorial and largely preventable physiological state that adversely affects nearly all functions of the body and comprises a significant public health threat

1. Te Huataki Waiora School of Health, The University of Waikato, New Zealand
2. Faculty of Health, Education and Environment, Toi Ohomai Institute of Technology, New Zealand
3. Sport and Exercise Science, School of Allied Health, Human Services and Sport, La Trobe University, Victoria
4. Aviation and Occupational Health Unit, Air New Zealand, New Zealand
5. New Zealand Rugby, New Zealand
Correspondence to: Daniel Wilson, Faculty of Te Huataki Waiora School of Health, University of Waikato, Adams Centre for High Performance, 52 Miro Street, Mount Maunganui 3116, New Zealand; e-mail: daniel.wilson@toiohomai.ac.nz
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and NCD risk.[15] Chronic high blood pressure is associated with numerous cardiovascular system pathologies and is a leading risk factor for global disease burden, with the worldwide prevalence of hypertension estimated as 31.1% in 2010.[16]

Sleep, nutrition and physical activity are each modifiable behavioural risk factors of chronic disease.[17] Obtaining adequate sleep, habitually consuming healthy dietary patterns and engaging in sufficient physical activity have a positive effect on physical and mental health,[8,17] significantly lower all-cause mortality and likely attenuate numerous NCD pathogenic processes.[18-20] Global prevalence of physical inactivity in 2016 was estimated as 27.5%, with an elevated rate of 42.3% in high-income Western countries.[21] Eighty-eight per cent of countries were estimated to be on average consuming insufficient vegetable intake in 2013,[22] and global figures indicated a decline in the average total number of hours of sleep obtained per night by adults.[23]

To date, the literature base pertaining to causal mechanisms between occupational factors and health outcomes in pilots is weak, and there is limited research quantifying the variance in health risk factor prevalence between pilots and the general population in New Zealand. The aim of this study is to explore the prevalence and distribution of NCD risk factors within airline pilots and compare these characteristics with an age and ethnicity matched general population representative sample.

Methodology

Design

A between-group, retrospective cross-sectional study was performed to evaluate the prevalence and distribution of health risk among airline pilots and the general population. This study examined health risk variables: age, sex, weight, body mass index (BMI), blood pressure, sleep duration, fruit and vegetable intake, physical activity levels and self-rated health. The outcome measures selected for this study were congruent with the 2018/19 New Zealand Health Survey (NZHS),[24] which was used to represent general population health risk data for comparison with pilots. This study was approved by the Human Research Ethics Committee of the University of Waikato in New Zealand (reference number 2019#35).

Participants

The pilot population consisted of commercial pilots from an international airline. Five hundred and four pilots volunteered to participate in the study (see Table 1). Pilots were invited to participate in the study at the time of completing their routine aviation medical examinations between 5 November 2019 and April 2021. Participants were from a combination of short-haul and long-haul rosters (n=261 and 243, respectively). Inclusion criteria were pilots who had a valid commercial flying license and worked on a permanent basis. All participants provided written informed consent prior to participation in the study and were made aware that they could withdraw from the study at any time should they wish to do so. Age, sex and ethnicity adjusted means, confidence intervals, and prevalence rates for health measures in the general population (n=2,033) were derived from the 2018/19 NZHS dataset, a National annual health survey that utilises a geographic sampling strategy with weights representative of the resident population, which is detailed elsewhere.[24] Data were collected for the 2018/19 NZHS between 1 July 2018 to 30 June 2019. The NZHS micro-dataset was provided by Statistics New Zealand for analysis in this study.

Procedures

At the time of their aviation medical appointment, pilots were invited to participate in the study by completing an electronic health questionnaire via an iPad (Apple, California, CA, USA) and providing consent to allow the researchers to access their anonymised aviation medical cardiovascular risk factor data. The electronic survey was constructed in Qualtrics software (Qualtrics, Provo, UT, USA) and consisted of questions about demographic information and health risk factor measures for sleep, nutrition, physical activity, and self-rated health. To support anonymity and dataset blinding during data analysis, participants were provided with a unique identification code on their informed consent form and were instructed to input it into their electronic survey instead of their name. Objective health risk measures for bodyweight and blood pressure were recorded by a clinical aviation medical professional during the pilot's aviation medical examination. All data from the NZHS were collected during interviews conducted at the respondent's home, which were carried out by a specialist survey provider contracted by the Ministry of Health.[24]

Outcome measures

Age at the date of response was calculated using date of birth. Measurements of height for pilots were recorded with a SECA 206 height measure and bodyweight was measured using SECA 813 electronic flat scales (SECA, Hamburg, Deutschland). In the NZHS, measurements for weight were recorded using Tanita HD-351 electronic weighing scales (Tanita, Tokyo, Japan) and height was recorded using laser height measurement.[25] For bodyweight measurement, scales were placed on a hard, flat surface and participants were wearing clothes and were asked to stand in the centre of the scales with their arms loosely by their sides and weight distributed on both feet. Two weight measurements were made to the nearest 0.1 kg. If the two measurements differed by more than 1%, a third measurement was made. The final weight measurement for each participant was calculated by averaging the two closest measurements. Data on height and weight were used to calculate body mass index (BMI), which was used to identify the proportion of participants who were underweight, a normal weight, overweight, or obese, as determined by scores of <18.5, 18.5–24.9, 25–29.9, and >30 (kg/m^2), respectively.[2,24]

Table 1: Demographic characteristics of the study populations.

Parameters	All subjects (n=2,537)	Pilots (n=504)	NZHS (n=2,033)
Sex (f/m)	44/2,547	44/460	0/2,033
Age (y)	46 ± 11	46 ± 10	46 ± 12
Caucasian (f/m)	44/2,481	44/448	0/2,033
Māori (f/m)	0/3	0/3	0/0
Indian (f/m)	0/7	0/7	0/0
Asian (f/m)	2/1	2/1	0/0

Notes:

Mean ± SD reported for age, total values are reported for all other variables.

Abbreviations: SD = standard deviation. f = female. m = male. NZHS = New Zealand Health Survey.

Measurements of blood pressure in pilots were conducted according to a standardised aviation medicine protocol.[26] Two blood pressure readings were measured with an OMRON HEM-757 device in a sitting position with the arm supported and held at the level of the atria. If the two initial readings were <140/<90, the lowest reading was recorded. If levels were >140/>90, two further readings at intervals of several minutes were taken. Measurements of blood pressure in the NZHS were made using standardised protocol[25] using an OMRON HEM-907 device, which automatically records heart rate, and systolic and diastolic blood pressure three times, with a one-minute pause between measurements. Blood pressure ranges were classified 'normal', 'at risk', and 'hypertension' as determined by values (systolic/diastolic) <120/<80, 120–139/80–89, and >140 and/or >90, respectively.[27]

Physical activity levels were assessed using the International Physical Activity Questionnaire Short Form (IPAQ-SF), a validated self-report measurement tool of moderate-to-vigorous physical activity (MVPA) that has been widely used in large cohort studies including the NZHS.[25] The IPAQ-SF estimates physical activity achievement by quantifying weekly walking, and moderate and vigorous physical activity duration and frequency. IPAQ-SF outcome measures derived were total weekly minutes of moderate and vigorous physical activity (MVPA) in bouts of ≥10 min, excluding walking, and total weekly minutes of walking in bouts of ≥10 min. Responses were capped at 3h/day and 21 h/week as recommended by IPAQ Guidelines.[28] Physical activity guidelines for health are >150 minutes moderate-intensity, or 75 minutes vigorous-intensity, or an equivalent combination MVPA per week.[29] Responses from the IPAQ were used to identify proportions of participants who were either obtaining little or no physical activity (<30 min MVPA), insufficient physical activity (30–149 min MVPA), sufficient physical activity (150–299 min MVPA), or exceeding guidelines (>300 min MVPA).

Fruit and vegetable intake was measured using two questions with acceptable validity and reliability derived from the New Zealand Health Survey.[25] The questions asked participants to report on average, over the past week how many servings of fruit and vegetables they had eaten per day. Showcards were used to help improve respondent engagement and the accuracy of their responses.[30] Responses to these questions were used to determine the proportion of participants who achieved daily intake health guidelines of ≥2 fruit servings, ≥3 vegetable servings, and ≥5 fruit and vegetable servings combined.[18]

Average self-reported sleep duration was measured via one question which asked how much sleep the respondent usually got in a 24-hour period, during the last month. Responses from this question were used to identify the proportion of participants who achieved health guidelines of ≥7 hours of sleep per night.[19]

Prospective cohort research suggests self-report health to be strongly associated with mortality risk and provides clinical and epidemiological value.[31] Subjective self-rated health was measured using the questions derived from the Short Health Form 12v2 (SF-12v2), a short version of the SF-36 that has demonstrated a high correlation with SF-36 scores[32] and good test-retest reliability and convergent validity to detect changes in mental and physical health in adults.[33] Responses were used to determine the responses for two discrete categories: a) poor or fair self-rated health; and b) good, very good or excellent self-rated health. All self-report health measures were congruent with those reported in the NZHS.

Statistical analysis

The NZHS data presented was age, sex and ethnicity adjusted to match the pilot population data. We reported absolute numbers, percentages, 95% confidence intervals (CIs), or means with standard deviations (mean ± SD). We calculated the prevalence and Clopper-Pearson binominal 95% CIs (exact method) for health risk measures and derived comparative values of the general population from the NZHS dataset. Additionally, we calculated the distribution by age group for each health risk. Subjects were categorised into age groups: 25–34, 35–44, 45–54 and 55–64 years, which were congruent with the NZHS data reporting. Adult age groups 18–24 and ≥65 years were not included in this study due to no pilot respondents within these age groups. Age-specific incidence rates among pilots were compared with corresponding rates in the general population of the NZHS.

Mean values for all outcome measures for each pilot age group was compared with the mean value for the corresponding age-sex-ethnicity adjusted group of the general population using a factorial analysis of variance (ANOVA). Health risk prevalence comparisons of significance between populations were performed with a Chi-squared test. To evaluate magnitude of differences, effect sizes were produced using Cohen's h for proportions and Cohen's d for means.[34] The magnitude of each effect size was interpreted using thresholds of 0.2, 0.5 and 0.8 for *small*, *moderate* and *large*, respectively.[34] The α level was set at a p-value of less than 0.05.

Raw data from survey responses were extracted from the Qualtrics online survey software (Qualtrics, Provo, UT, USA), entered into an Excel spreadsheet (Microsoft, Seattle, WA, USA) and then imported into statistical software SPSS v24 for Windows (IBM, New York, NY, USA) and MedCalc Statistical Software v20 (MedCalc, Ostend, Belgium, https://www.med-calc.org). Listwise deletion was applied for individual datasets with missing values or participants who did not complete all electronic survey components.

Results

The pilot population was heavily skewed towards male sex (91.2%) and Caucasian ethnicity (97.4%), which excluded analysis of data on female pilots and non-Caucasian ethnicities due to inadequate sample size to detect meaningful inferences for these subgroups. Similar demographic trends have been published in previous studies within commercial pilots.[1,2] Therefore, from the 504 pilots who volunteered to participate in this study, 460 were included in the data analysis, which represents approximately 33% of the pilot population within the airline. From the 13,572 adult responses available in the NZHS 2018/19, data from 2,033 general population participants were included in our analysis after adjustment for age-sex-ethnic demographics of the pilot population. According to the NZ Census 2018,[35] this sample represents 0.25% of the male Caucasian population in NZ between the ages of 25–64 years. The NZHS recruited participants evenly among the age groups, whereas the age distribution of the airline pilots was more reflective of a working population, with fewer pilots in the youngest and oldest age groups.

The health risk characteristics among pilots and the general population are given in Table 1 and comparison of health risk prevalence between groups are presented in Table 2.

Table 2: Demographic and health risk characteristics among airline pilots and the general population.

	Airline pilots (n=460)				General population (n=2,033)							
	25-34y (n=68)	35-44y (n=134)	45-54y (n=153)	55-64y (n=105)	25-34y (n=433)	ES	35-44y (n=438)	ES	45-54y (n=527)	ES	55-64y (n=635)	ES
Objective measures												
Height (cm)	182 (181–184)	181 (180–182)	180 (179–181)	179 (178–180)	178 (178–179)**	0.60	179 (178–179)*	0.27	178 (177–178)**	0.45	176 (175–176)**	0.48
Weight (kg)	86 (82–90)	86 (84–88)	88 (86–90)	87 (85–89)	88 (86–89)	-0.07	90 (88–91)*	-0.21	91 (89–93)*	-0.19	90 (88–91)	-0.17
BMI (kg/m2)	25.9 (25–27)	26.3 (26–27)	27 (26–27)	27 (27–28)	28 (27–28)*	-0.33	28 (28–29)**	-0.35	29 (28–29)**	-0.38	29 (28–30)**	-0.40
Systolic BP (mmHg)	129 (126–132)	129 (127–131)	131 (129–133)	136 (133–138)	126 (125–127)	0.19	126 (125–127)*	0.23	130 (128–131)	0.08	135 (134–137)	0.02
Diastolic BP (mmHg)	76 (74–78)	80 (78–80)	83 (81–84)	84 (83–86)	74 (73–75)	0.17	76 (75–77)**	0.33	80 (79–81)*	0.24	80 (79–81)**	0.41
Average BP (mmHg)	102 (100–105)	104 (103–106)	107 (105–108)	110 (108–112)	100 (99–101)	0.20	101 (100–102)*	0.29	105 (104–106)	0.16	107 (106–109)	0.18
Subjective measures												
Sleep (hours)	7.3 (7.1–7.5)	7.1 (7.0–7.2)	6.9 (6.8–7.1)	7.0 (6.9–7.2)	7.4 (7.3–7.5)	-0.08	7.1 (7.0–7.2)	-0.06	7.2 (7.1–7.3)*	-0.19	7.1 (7.0–7.2)	-0.07
Total PA (min)	219 (194–245)	217 (199–235)	220 (201–239)	204 (185–224)	1,001 (899–1103)**	-0.78	919 (816–1022)**	-0.73	859 (775–943)**	-0.74	872 (799–945)**	-0.77
Health "Excellent" (n,%)	1 (1.5%)	2 (2%)	2 (1%)	2 (2%)	42 (10%)	-0.39	53 (12%)	-0.46	49 (9%)	-0.39	73 (12%)	-0.42
Health "Very good" (n,%)	17 (25%)	22 (16%)	13 (9%)	11 (11%)	196 (45%)	-0.43	164 (37%)	-0.48	217 (41%)	-0.80	221 (35%)	-0.60
Health "Good" (n,%)	39 (57%)	81 (60%)	95 (62%)	59 (56%)	142 (33%)	0.50	167 (38%)	0.45	191 (36%)	0.52	249 (39%)	0.34
Health "Fair" (n,%)	10 (15%)	25 (19%)	37 (24%)	29 (28%)	48 (11%)	0.11	46 (11%)	0.23	60 (11%)	0.34	66 (10%)	0.45
Health "Poor" (n,%)	1 (1.5%)	4 (3%)	6 (4%)	4 (4%)	5 (1%)	0.03	8 (2%)	0.08	10 (2%)	0.12	26 (4%)	-0.02

Notes:
Data are means with Copper-Pearson 95% CIs in parentheses or counts and percentages in parentheses.
** indicates statistical significance (p < 0.05). ** indicates statistical significance (p < 0.001).*
Abbreviations: n = sample size. BMI = Body Mass Index. PA = Physical Activity. Total PA = combined weekly walking, moderate and vigorous physical activity minutes. BP = Blood Pressure. Average BP = systolic/diastolic. ES = Effect Size (Cohen's d for means and Cohen's h for percentages).

On average, pilots were significantly taller (p=<0.05, d=0.45) and had a lower BMI across all age groups (p=<0.05, d=0.37). Further, pilots had shorter sleep duration in age group 45–54 (p=<0.05, d=-0.19), higher average blood pressure in age group 35–44 (p=<0.001, d=0.29), and lower total weekly PA minutes across all age groups (p=<0.001, d=0.74-0.78), see Table 1.

The prevalence and distribution of health risk factors between pilots and the general population across age groups are depicted in Figure 1. Both groups had an increase in the prevalence of overweight and obesity, hypertension, short sleep, and poor and fair self-rated health with increased age (Figure 1). Pilots had significantly lower (p=<0.001, d=-0.41) prevalence of obesity across all age groups (Figure 2). Overall, the difference between the prevalence of overweight and obesity was not statistically significant between the general population and pilots (p=0.20, 74.5% and 66.8%, respectively).

The prevalence of hypertension did not significantly differ between groups overall (p=0.79, h=-0.01). A significantly higher proportion of pilots were 'at risk' for hypertension (p=<0.001, h=-0.34). For the age group 35-44 years, pilots had significantly higher prevalence of hypertension (p=<0.001, h=0.16), whereas pilots aged 55–64 had a significantly lower prevalence (p=0.03, h=-0.11).

Overall self-report sleep duration was higher in the general population compared to pilots (p=<0.001, d=0.12, 7h 3.6min and 7h 11.4min, respectively). The proportion of participants who achieved >7 hours of sleep per night was higher in the general population compared to pilots overall (p=0.12, 75.5% and 66.5%, respectively) and was significantly higher for age groups 25–34, 45–54, and 55–64 (p=<0.05, h=0.32, 0.20, 0.14, respectively).

More pilots achieved >5 servings of self-report fruit and vegetables daily compared to the general population (p=0.002, h=0.16). Total self-report PA weekly minutes were significantly higher in the general population across all age groups (p=<0.001, d=0.74-0.78), yet there was no overall significant difference in the prevalence of achieving >150 min MVPA per week (p=0.22, h=0.11).

The prevalence of self-rated health being 'good', 'very good' or 'excellent' was significantly higher in the general population compared to pilots (p=<0.001, h=0.31), with the prevalence of 'poor' or 'fair' ratings increasing with age in both groups.

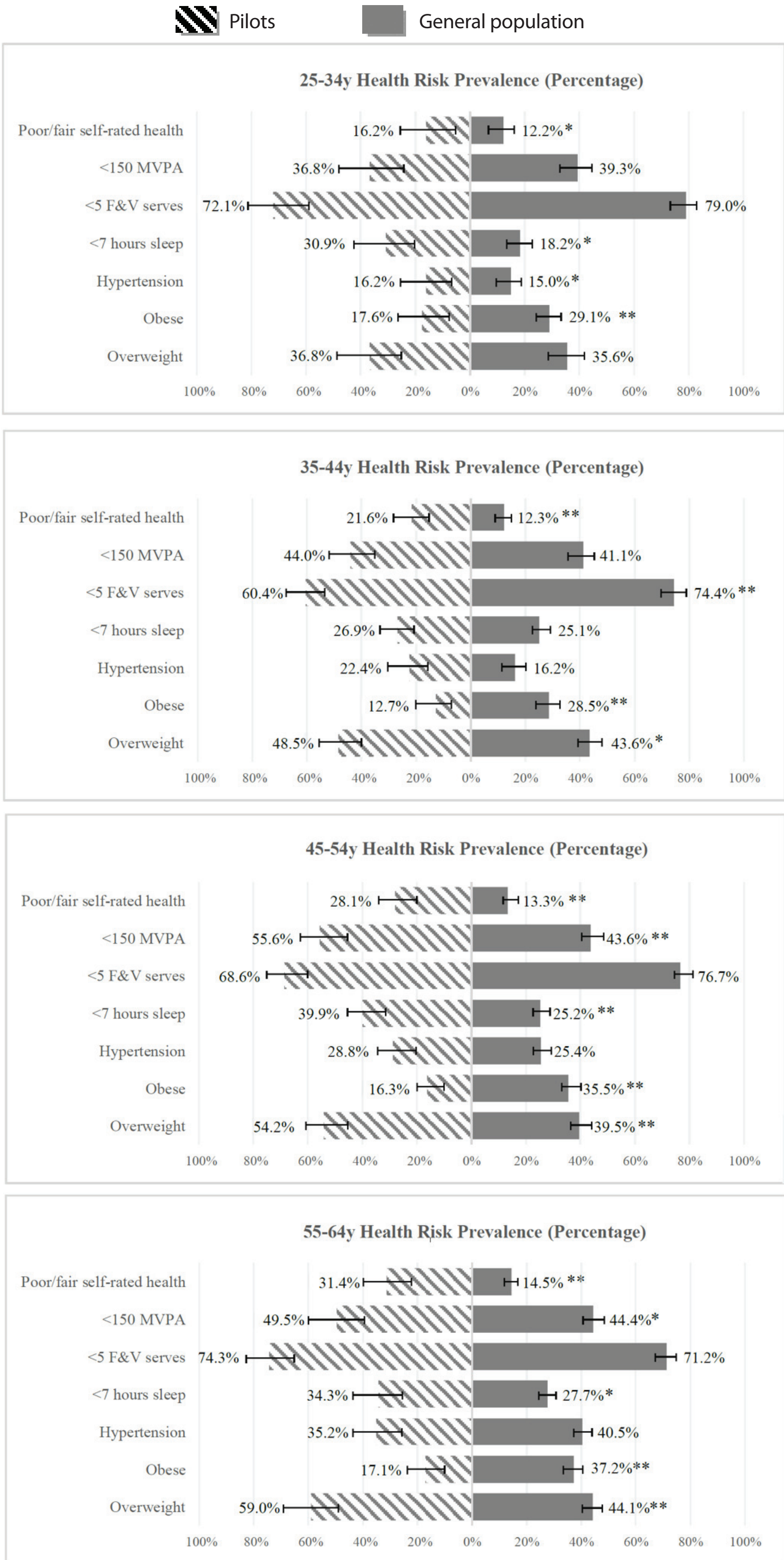
Discussion

To our knowledge, no previous studies have explored physical, health behaviour and self-report health risk factors together in an independent cross-sectional study among airline pilots, nor have any studies compared health behaviour characteristics in this occupational group with the general population. Some of our findings about demographic and health risks were identified that are consistent with past research in pilots. These included a high proportion of male pilots compared to females,[1,2] pilots having lower incidence of a BMI exceeding 25 (overweight and obesity),[1,2] and notable prevalence of risk factors for sleep,[11,12] nutrition,[8] and physical activity.[5,8] Our research adds preliminary quantification of the prevalence of hypertension in NZ pilots and behavioural health risk factors of sleep duration, fruit and vegetable intake and physical activity in pilots, which to date have been largely unexplored in the literature.

Studies have previously examined cardiovascular disease-related health risk factors within commercial pilots. Past research in NZ pilots identified the mean BMI as 27.1 and obesity incidence as "almost 20%".[1] Comparatively, we found an overall lower mean BMI of 26.6 and an obesity prevalence of 15.7%. Overall, we found pilots had a significantly lower prevalence of obesity than the general population. Similarly, a previous cross-sectional UK-based study reported significantly lower overweight and obesity in pilots (46.8% and 12.4%, respectively) compared to the general population (47% and 21%, respectively), with a significantly lower overall mean BMI in pilots.[2] The prevalence in other countries have been reported as 39%[36] and 53.7%[37] for overweight, and 7.3%[36] and 14.6%[37] for obesity in Indian and Spanish pilots, respectively.

In the present study, an evident trend across age groups were statistically significant higher rates of overweight and lower rates of obesity in pilots compared to the general population, which is congruent with previous research.[2] Thus, although the overall prevalence of overweight and obesity was not significantly different to the general population, fewer pilots were categorised as obese, which is associated with increased NCD risk compared to those who are <29 BMI.[38] Consequently, the pilot population may have a lower risk of obesity-related

Figure 1: Comparison of health risk prevalence in between airline pilots and the general population.



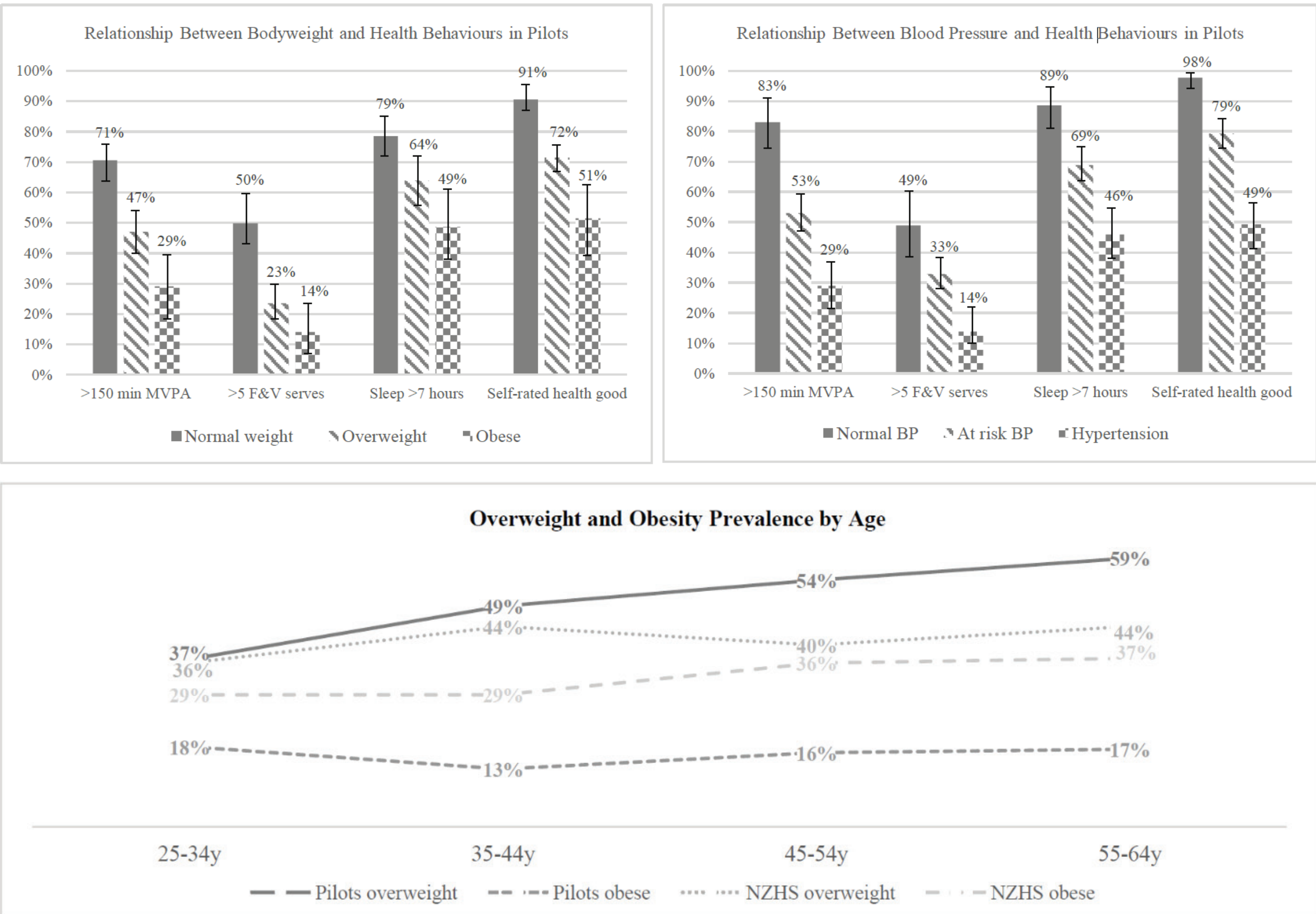
Notes:
Data are expressed as prevalence percentage of the overall population by age group.
F&V = Fruit and vegetable serves.
** indicates statistical significance (p < 0.05); ** indicates statistical significance (p < 0.001).*
Confidence intervals are presented for all data.

disease incidence than that of the general population. Previous studies have proposed potential protective factors that may contribute to the mitigation of adverse health outcomes in pilots, including the healthy worker effect, pilots being subject to regular medical examinations and socioeconomic status.[1,39]

To our knowledge, hypertension incidence has not been previously reported for NZ pilots. Within UK pilots, a significantly higher prevalence of hypertension was reported for males in age groups <25 and 35–44 years, with significantly lower rates in age groups 45–54 and 55–64, compared to the general population.[2] We found an overall pilot population hypertension prevalence of 26.5%, and higher rates of hypertension in pilots across ages 25–54 years compared to the general population, yet only the 35–44 age group was statistically significant. Comparatively, this incidence rate is lower than previously reported hypertension rates of 28.3% in Chinese pilots,[10] 28.7% in UK pilots[2] and 38% in Spanish pilots.[37] Conversely, a much lower hypertension rate of 4.1% was reported in a sample of Indian pilots.[36]

A limited number of studies have reported sleep duration, dietary behaviours and physical activity within airline pilots and there are no studies comparing these health behaviours of pilots with the general population. There is a dearth of literature pertaining to the distribution of sleep duration among different pilot age groups. We found 66.5% of pilots overall achieved ≥7 hours of sleep, which was 9% lower than the general population. Further, we observed sleep duration decreased with increased age in both groups, which is consistent with previously reported age-associated degradation of sleep quality and quantity.[40] Pilots had an average sleep duration of 7 hours and 4 minutes overall, with no difference to the general population for age groups below 45 years, however, a reduced sleep duration in age groups >45 years compared to groups younger than 45 was noted, which was significantly lower than the general population. Indeed, a previous study identified >64% of pilots achieve less than 7 hours of sleep per night on average during off-duty periods.[11] Whereas, another study objectively measured sleep and reported 23% of pilots averaged <6 hours of sleep habitually.[12] Sleep disruption is an inherent risk for pilots, who have occupationally induced perturbations to the natural circadian rhythm, including shift work, extended duty periods, travelling across time zones, sleep restrictions associated with short layovers, regularly changing work/rest schedules, and regular changes in the sleeping environment (for example, at home, onboard, and in hotels),[41,42] all of which may contribute to lower sleep duration in contrast to the general population. Furthermore, long-haul pilots often do not follow a normal

Figure 2: Health risk trends within airline pilots.



Notes:
Data are expressed as prevalence percentage of the overall population.
F&V = Fruit and Vegetable serves.
The "underweight" bodyweight category was omitted from Chart 1 due to insufficient sample size for this subgroup (n=4).

day/night sleep pattern with a single long sleep at night, as do the general population. For example, a long-haul pilot may have a pre-flight nap, potentially multiple short periods of sleep in the crew bunk during the flight (1 to 2 hours), and then a 4–5-hour post-arrival sleep, followed by an overnight sleep on subsequent layover nights and then repeating the process on the return leg. Thus, self-report questions pertaining to average sleep in a 24-hour period may be difficult to interpret for pilots and may influence the overall average sleep duration reported.

Occupational duties of airline pilots involve prolonged periods of sedentary time sitting in the cockpit and at airports.[1,5] Insufficient physical activity is a prevalent source of work-related stress,[13] and indeed, lower levels of physical activity are associated with daytime sleepiness and fatigue in pilots.[7] Our study is the first to explore the proportion of pilots attaining the World Health Organization's MVPA guidelines[29] compared with the general population. Fifty-one per cent of pilots achieved ≥150 min MVPA per week, compared to 57.6% in the general population, indicating nearly half of the overall population in both groups were not sufficiently physically active. These findings are similar, yet higher than a previously reported 42.3% global estimate of physical inactivity in high-income Western countries.[21] Three previous studies have reported weekly physical activity on average, to be <150 minutes of MVPA per week within pilot populations,[5,8,43] whereas two other studies reported days per week achieving ≥30 minutes of moderate activity as 3.2 to 3.4 days per week.[7,11] To date, the limited evidence base suggests low rates of physical activity in pilots, yet no research has critically examined the validity of self-report physical activity measurements compared to objective measures such as accelerometry in pilots.

Work-related characteristics of pilots including irregular and long duty periods, perceived fatigue, disrupted sleep and unhealthy food availability in the work environment may affect dietary behaviour.[1,3,13] Our study is the first to explore the proportion of pilots who achieve the widely advocated health behaviour of consuming ≥5 servings of fruit and vegetables per day for health risk reduction benefits.[18] A previous study in a small sample (n=79) of NZ based airline pilots reported an average of 3.6 servings of fruit and vegetable per day,[8] yet extremely few published studies have addressed dietary behaviours in pilots.

Table 3: The prevalence of health risk factors among airline pilots and the general population overall.

	Pilots (n=460)	NZHS (n=2,033)	*p* value	Effect size (Cohen's h)	OR (95% CI)
Bodyweight					
Underweight BMI	4/460 (0.9%)	11/2,033 (5.0%)	0.411	0.16	1.60 (0.50–5.06)
Normal weight	149/460 (32.4%)	515/2,033 (25.3%)	0.002	0.16	1.27 (1.03–1.57)
Overweight	235/460 (51.1%)	833/2,033 (41.0%)	<0.001	0.20	1.24 (1.03–1.48)
Obese	72/460 (15.7%)	674/2,033 (33.2%)	<0.001	-0.41	0.47 (0.36–0.61)
Blood pressure					
Normal	88/460 (19.1%)	745/2,033 (36.6%)	<0.001	-0.39	0.52 (0.40–0.66)
At risk	250/460 (54.3%)	758/2,033 (37.3%)	<0.001	0.34	1.45 (1.22–1.73)
Hypertension	122/460 (26.5%)	527/2,033 (25.9%)	0.791	0.01	1.02 (0.81–1.27)
Sleep					
<5 hours per night	0/460 (0.0%)	45/2,033 (2.2%)	0.001	-0.30	0.04 (0.00–0.78)
5-6 hours per night	3/460 (0.7%)	93/2,033 (4.6%)	<0.001	-0.26	0.14 (0.04–0.45)
6-7 hours per night	151/460 (32.8%)	360/2,033 (17.7%)	<0.001	0.35	1.85 (1.49–2.29)
7-8 hours per night	263/460 (57.2%)	697/2,033 (34.3%)	<0.001	0.46	1.66 (1.40–1.98)
8-9 hours per night	39/460 (8.5%)	666/2,033 (32.8)	<0.001	-0.63	0.25 (0.18–0.36)
>9 hours per night	4/460 (0.9%)	172/2,033 (8.5%)	<0.001	-0.40	0.10 (0.03–0.27)
Nutrition					
<2 fruit servings	277/460 (60.2%)	1,156/2,033 (56.9%)	0.189	0.07	1.05 (0.89–1.24)
>2 fruit servings	183/460 (39.8%)	877/2,033 (43.1%)	0.189	-0.07	0.92 (0.76–1.11)
<3 vegetable servings	220/460 (47.8%)	1,069/2,033 (52.6%)	0.065	-0.10	0.90 (0.76–1.08)
>3 vegetable servings	240/460 (52.2%)	964/2,033 (47.4%)	0.065	0.10	1.10 (0.92–1.30)
<5 fruit and vegetable servings	313/460 (68.0%)	1,524/2,033 (75.0%)	0.002	-0.16	0.90 (0.77–1.06)
>5 fruit and vegetable servings	147/460 (32%)	509/2,033 (25.0%)	0.002	0.16	1.27 (1.03–1.57)
Physical Activity					
Little or none	40/460 (8.7%)	193/2,033 (9.5%)	0.596	-0.03	0.91 (0.64–1.30)
Insufficient	181/460 (39.3%)	669/2,033 (32.9%)	0.008	0.13	1.19 (0.98–1.45)
Sufficient	208/460 (45.2%)	108/2,033 (5.3%)	<0.001	1.01	8.51 (6.60–10.96)
Heavy	31/460 (6.7%)	1,063/2,033 (52.3%)	<0.001	-1.09	0.12 (0.08–0.18)
Self-rated health					
Poor or fair	116/460 (25.2%)	269/2,033 (13.2%)	<0.001	0.31	1.90 (1.49–2.42)
Good, very good or excellent	344/460 (74.8%)	1,764/2,033 (86.8%)	<0.001	-0.31	0.86 (0.73–1.00)

Notes:

Data are proportion counts with percentage in parentheses.

NZHS = New Zealand Health Survey. BMI = Body mass index. OR = Odds ratio.

We found the proportion of pilots overall who achieved a daily intake of ≥5 servings of fruit and vegetable was significantly higher than the general population (p=0.002, 32% and 25%, respectively). Nevertheless, more than two-thirds of pilots and the general population were not achieving fruit and vegetable intake guidelines, highlighting the major prevalence of this behavioural risk factor. Similarly, a global epidemiological analysis reported 88% of countries they examined did not achieve vegetable intake guidelines.[22] Thus, evidence-driven interventions to encourage vegetable consumption are of public health importance.[22]

In our study, a relationship between health behaviours, overweight and obesity was evident, where overweight and obesity were associated with lower fruit and vegetable intake, less weekly MVPA and shorter sleep duration compared to pilots having a BMI of ≤25 (Figure 2). These findings are comparative to a previous study within Brazilian pilots, which identified factors associated with obesity were sleeping <6 hours on days off, <150 min of weekly physical exercise, number of years working as a pilot, and presence of daytime sleepiness.[5] Further, a cross-sectional investigation into health-related quality of life and its related factors among civilian pilots concluded physical activity and fruit and vegetable intake were positively correlated with quality of life.[6] Thus, targeted strategies to improve health behaviour in pilots may promote healthy weight, blood pressure management and quality of life, yielding positive NCD risk reduction effects.

Limitations of this study need to be considered regarding the interpretation of our findings. Firstly, as outcome measures were recorded for pilots in the aviation medicine clinic during their routine aviation medical examination, and data collected for the general population in their home residence, these environmental differences may have a potential influence on findings. In particular, in-clinic blood pressure measurement may be less accurate in the detection of true resting blood pressure values than measurement at home[44] and may account for the increase in blood pressure observed in pilots. Nevertheless, measurements were taken congruent with standardised aviation medicine blood pressure protocols,[26] which are established to mitigate the risk of false readings. Future research in pilots should investigate home blood pressure measurement readings compared to blood pressure recordings during aviation medical examinations to quantify whether significant environmental variance exists. Secondly, as pilot population data collection coincided with the emergence of the COVID-19 pandemic, the global novel pandemic environmental circumstances may have influenced some differences observed between study populations. Third, some self-selection bias may be present; those pilots who voluntarily participated may be more likely to have a greater active interest in their personal health than pilots who did not choose to participate. Finally, for feasibility reasons, self-report methods were used in this study. These methods have their own inherent limitations including reliance on participant recall ability and they are subject to over- or under-estimation responses.[45] To strengthen the validity of our findings and better inform targeted health promotion interventions for pilots, future research should examine dietary behaviours via direct or indirect measures of dietary recall, such as photo food logging, food frequency questionnaires and 24-hour recalls on both flying and non-flying days, to provide more comprehensive characterisation of dietary patterns in this occupational group. Further, quantification of sleep patterns and habitual physical activity levels should be explored using objective methods such as actigraphy.

Civil Aviation Regulators are required to apply safety management principles to the pilot medical assessment process, evaluate data on areas of increased health risk, and implement appropriate health promotion for pilots to reduce future medical risks to flight safety, as outlined in the International Civil Aviation Organization's Annex 1.[46] Based on present findings, we advocate aviation health and occupational safety professionals and researchers to further examine targeted, cost-effective intervention methods for promoting healthy bodyweight, managing blood pressure and enhancing health behaviours to mitigate risks of occupational morbidity, medical conditions causing loss of license, medical incapacity, and to support flight safety.

Conclusion

This study found pilots had a similar prevalence of NCD risk factors with the general population overall, yet a lower incidence of a BMI exceeding 30 (obesity) and a higher fruit and vegetable intake than the general population. We found preliminary evidence of those 'at risk' for hypertension, less total weekly physical activity, shorter sleep duration and lower self-rated health than the general population. Both pilots and the general population had an increase in the prevalence of overweight and obesity, hypertension, short sleep, and poor and fair self-rated health with increased age. Future research should investigate home blood pressure measurement and health behaviour quantification with objective measures to strengthen the validity of our study's findings.

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References

1. Sykes AJ, Larsen PD, Griffiths RF, Aldington S. A study of airline pilot morbidity. *Aerosp Med Hum Perform.* 2012;83(10):1001-5.
2. Houston S, Mitchell S, Evans S. Prevalence of cardiovascular disease risk factors among UK commercial pilots. *Eur J Prev Cardiol.* 2011;18(3):510-17.
3. Reis C, Mestre C, Canhão H, Gradwell D, Paiva T. Sleep complaints and fatigue of airline pilots. *Sleep Sci.* 2016;9(2):73-7.
4. Miura K, Olsen CM, Rea S, Marsden J, Green AC. Do airline pilots and cabin crew have raised risks of melanoma and other skin cancers? Systematic review and meta-analysis. *Br J Dermatol.* 2019;181(1):55-64.
5. de Souza Palmeira ML, Cristina Marqueze E. Excess weight in regular aviation pilots associated with work and sleep characteristics. *Sleep Sci.* 2016;9(4):266-71.
6. Liu T, Qiu B, Zhang C, Deng M, Liang Z, Qi Y. Health-related quality of life in pilots of a Chinese commercial airline. *Arch Environ Occup Health.* 2021;76(8):511-17.
7. van Drongelen A, Boot CRL, Hlobil H, Smid T, van der Beek AJ. Risk factors for fatigue among airline pilots. *Int Arch Occup Environ Health.* 2017;90(1):39-47.
8. Wilson D, Driller M, Johnston B, Gill N. The effectiveness of a 17-week lifestyle intervention on health behaviors among airline pilots during COVID-19. *J Sport Health Sci.* 2021;10(3):333-40.
9. Albermann M, Lehmann M, Eiche C, Schmidt J, Prottengeier J. Low back pain in commercial airline pilots. *Aerosp Med Hum Perform.* 2020;91(12):940-7.
10. Chen X, Xie L, Liu Y, et al. Metabolic syndrome and periodontal disease among civilian pilots. *Aerosp Med Hum Perform.* 2016;87(12):1016-20.
11. van Drongelen A, Boot CR, Hlobil H, Twisk JW, Smid T, van der Beek AJ. Evaluation of an mHealth intervention aiming to improve health-related behavior and sleep and reduce fatigue among airline pilots. *Scand J Work Environ Health.* 2014;40(6):557-68.
12. Wu LJ, Gander PH, van den Berg MJ, Signal TL. Estimating long-haul airline pilots' at-home baseline sleep duration. *Sleep Health.* 2016;2(2):143-5.
13. Cahill J, Cullen P, Anwer S, Wilson S, Gaynor K. Pilot Work Related Stress (WRS), effects on wellbeing and mental health, and coping methods. *Int J Aviat Psychol.* 2021;31(2):87-109.
14. Bennett JE, Kontis V, Mathers CD, et al. NCD Countdown 2030: Pathways to achieving sustainable development goal target 3.4. *Lancet.* 2020;396(10255):918-34.
15. Chooi YC, Ding C, Magkos F. The epidemiology of obesity. *Metabolism.* 2019;92:6-10.
16. Mills KT, Stefanescu A, He J. The global epidemiology of hypertension. *Nat Rev Nephrol.* 2020;16(4):223-37.
17. Mozaffarian D, Wilson PW, Kannel WB. Beyond established and novel risk factors: Lifestyle risk factors for cardiovascular disease. *Circulation.* 2008;117(23):3031-8.
18. Bellavia A, Larsson SC, Bottai M, Wolk A, Orsini N. Fruit and vegetable consumption and all-cause mortality: A dose-response analysis. *Am J Clin Nutr.* 2013;98(2):454-9.
19. Cappuccio FP, D'Elia L, Strazzullo P, Miller MA. Sleep duration and all-cause mortality: A systematic review and meta-analysis of prospective studies. *Sleep.* 2010;33(5):585-92.
20. Lear SA, Hu W, Rangarajan S, et al. The effect of physical activity on mortality and cardiovascular disease in 130 000 people from 17 high-income, middle-income, and low-income countries: The PURE Study. *Lancet.* 2017;390(10113):2643-54.
21. Guthold R, Stevens GA, Riley LM, Bull FC. Worldwide trends in insufficient physical activity from 2001 to 2016: A pooled analysis of 358 population-based surveys with 1.9 million participants. *Lancet Glob Health.* 2018;6(10):e1077-86.
22. Kalmpourtzidou A, Eilander A, Talsma EF. Global vegetable intake and supply compared to recommendations: A systematic review. *Nutrients.* 2020;12(6):1558.
23. Chattu VK, Sakhamuri SM, Kumar R, Spence DW, BaHammam AS, Pandi-Perumal SR. Insufficient sleep syndrome: Is it time to classify it as a major noncommunicable disease? *Sleep Sci.* 2018;11(2):56-64.
24. New Zealand Government Ministry of Health. *Methodology Report 2018/19: New Zealand Health Survey* [Internet]. Wellington (NZ): Government of New Zealand; 2019 [cited 2021 Apr 27]. Available from: https://www.health.govt.nz/system/files/documents/publications/methodology-report-2018-19-new-zealand-health-survey-nov19.pdf
25. New Zealand Government Ministry of Health. *Content Guide 2018/19: New Zealand Health Survey* [Internet] Wellington (NZ): Government of New Zealand; 2019 [cited 2021 Apr 27]. Available from: https://www.health.govt.nz/system/files/documents/publications/content-guide-2018-19-new-zealand-health-survey-nov19.pdf
26. Civil Aviation Authority. *Medical Manual Part 3 - Clinical Aviation Medicine* [Internet]. Wellington (NZ): CAA; 2021 [cited 2021 Apr 27]. Available from: https://www.aviation.govt.nz/assets/publications/medical-manual/Med_Man_Part-3.pdf
27. Chobanian AV, Bakris GL, Black HR, et al. Seventh Report of the Joint National Committee on prevention, detection, evaluation, and treatment of high blood pressure. *Hypertension.* 2003;42(6):1206-52.

28. IPAQ Research Committee. *Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ) - Short and Long Forms* [Internet]. Stockholm (SWE): Karolinska Institutet; 2005 [cited 2020 Jul 2]. Available from: https://sites.google.com/site/theipaq/scoring-protocol
29. World Health Organization. *Global Recommendations on Physical Activity for Health.* Geneva (CHE): WHO; 2010.
30. New Zealand Government Ministry of Health. *Adult Questionnaire Showcards: Year 9 - 2018/19* [Internet]. Wellington (NZ): Government of New Zealand; 2019 [cited 2021 Apr 27]. Available from: https://www.health.govt.nz/system/files/documents/publications/adult-nzhs-showcards-2018-19.pdf
31. Lorem G, Cook S, Leon DA, Emaus N, Schirmer H. Self-reported health as a predictor of mortality: A cohort study of its relation to other health measurements and observation time. *Sci Rep.* 2020;10(1):4886.
32. Ware JE, Keller SD, Kosinski M. *SF-12: How to Score the SF-12 Physical and Mental Health Summary Scales.* Boston (MA): New England Medical Center Health Institute; 1995.
33. Cheak-Zamora NC, Wyrwich KW, McBride TD. Reliability and validity of the SF-12v2 in the medical expenditure panel survey. *Qual Life Res.* 2009;18(6):727-35.
34. Cohen J. *Statistical Power Analysis for the Behavioral Sciences.* 2nd ed. Florence (ITA): Taylor & Francis Group; 1988.
35. Statistics New Zealand. *2018 Cencus Ethnic Group Summaries*. Wellington (NZ):Government of New Zealand; 2021.
36. Bhat KG, Verma N, Pant P, Singh Marwaha MP. Hypertension and obesity among civil aviation pilots. *Aerosp Med Hum Perform.* 2019;90(8):703-8.
37. Alonso-Rodríguez C, Medina-Font J. High sensitivity C-reactive protein in airline pilots with metabolic syndrome. *Aviat Space Environ Med.* 2012;83(5):504-8.
38. Janssen I, Katzmarzyk PT, Ross R. Body mass index, waist circumference, and health risk: Evidence in support of current National Institutes of Health guidelines. *Arch Intern Med.* 2002;162(18):2074-9.
39. Pizzi C, Evans SA, De Stavola BL, Evans A, Clemens F, Silva Idos S. Lifestyle of UK commercial aircrews relative to air traffic controllers and the general population. *Aerosp Med Hum Perform.* 2008;79(10):964-74.
40. Li J, Vitiello MV, Gooneratne NS. Sleep in normal aging. *Sleep Med Clin.* 2018;13(1):1-11.
41. Caldwell JA. Fatigue in aviation. *Travel Med Infect Dis.* 2005;3(2):85-96.
42. Roach GD, Petrilli RMA, Dawson D, Lamond N. Impact of layover length on sleep, subjective fatigue levels, and sustained attention of long-haul airline pilots. *Chronobiol Int.* 2012;29(5):580-6.
43. Wilson D, Driller M, Winwood P, Johnston B, Gill N. The effects of a brief lifestyle intervention on the health of overweight airline pilots during COVID-19: A 12-month follow-up study. *Nutrients.* 2021;13(12):4288.
44. Sivén SSE, Niiranen TJ, Kantola IM, Jula AM. White-coat and masked hypertension as risk factors for progression to sustained hypertension: The Finn-Home Study. *J Hypertens.* 2016;34(1):54-60.
45. Brutus S, Aguinis H, Wassmer U. Self-reported limitations and future directions in scholarly reports: Analysis and recommendations. *J Manage.* 2013;39(1):48-75.
46. International Civial Aviation Authority. *The Convention on International Civil Aviation: Annex 1* [Internet]. Montreal (CAN): ICAO; 2018 [cited 2021 May 10]. Available from: http://web.shgm.gov.tr/documents/sivilhavacilik/files/pdf/saglik_birimi/ICAO_Annex_1_12th.pdf