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Assessment of the leptin levels and carbohydrate metabolism among female flight attendants

Ocena stężenia leptyny i gospodarki węglowodanowej u stewardess

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Abstract

Key words: *leptin, shift work, flight attendants, carbohydrate metobolism*

Introduction and objective: The work of flight attendants is associated with exposure to disturbances in the circadian rhythm, sleep deficiency or deprivation, and irregular meal consumption. These factors may lead to disrupted leptin secretion and an increased risk of carbohydrate metabolism disorders. The aim of the study was to determine the level of leptin, glucose and insulin patterns and to seek factors of potential influence on the secretion of leptin, glucose and insulin in female flight attendants working within one time zone (more take-offs and more landings) as well as on long-distance flights.

Material and methods: The cross-sectional study involved 103 Polish women aged 23–46, divided into two groups: Ia - flying within one time zone and group Ib - stewardesses working on long-distance flights. The control group (II) comprised women seeking help for marital infertility (male factor). Variables assessed included age, BMI, menstrual cycle regularity, service length, flying frequency, leptin concentration, OGTT, insulin pattern, and HOMA-IR. Descriptive and inferential statistical methods were used for data analysis.

Results: The incidence of hyperleptinemia in female flight attendants (22%) was significantly higher than in the control group (6%), p <0,05. Groups Ia and Ib in individual concentrations were not statistically significant (p=0.118). Impaired Glucose Tolerance (IGT) was found in 10% of the study group and 5% of women in the control group. Hyperinsulinemia occurred slightly more frequently in flight attendants, especially in those flying on long-distance flights, working less frequently, and having longer work experience

Conclusions: The specific working conditions of flight attendants, especially their shift work nature, contribute to a higher prevalence of hyperleptinemia. Considering the fact that Impaired Glucose Tolerance occurs two times more frequently in flight attendants, it is reasonable to assume that this occupational group is at risk of developing diabetes in the future.

Streszczenie

Słowa kluczowe: *leptyna, praca zmianowa, stewardessy, gospodarka węglowodanowa*

Wprowadzenie i cel: Praca stewardess wiąże z narażeniem na zaburzenia rytmu dobowego, niedobór lub deprywację snu, a także na nieregularne spożywanie posiłków. Wymienione czynniki mogą powodować zaburzone wydzielanie leptyny oraz zwiększone ryzyko wystąpienia zaburzeń gospodarki węglowodanowej.Celem pracy było określenie częstości występowania hiperleptynemii i potencjalnych czynników na nią wpływających u stewardes pracujących w jednej strefie czasowej lub na trasach długodystansowych.

Materiał i metody: Badaniem przekrojowym objęto 103 kobiety, w wieku 23-46 lat. Grupę badaną (I) stanowiły stewardessy, które pracowały zarówno w obrębie jednej strefy czasowej jak i na lotach długodystansowych. Grupę kontrolną (II) stanowiło 60 kobiet w okresie reprodukcyjnym, które zgłaszały się do lekarza z powodu niepłodności, u których za przyczynę niepłodności małżeńskiej uznano czynnik męski. Ocenie poddano: wiek, wskaźnik masy ciała, regularność cykli menstruacyjnych, staż pracy, częstotliwość lotów, stężenie leptyny, doustny test tolerancji glukozy i insuliny oraz HOMA-IR. Dla opracowania danych zastosowano metody opisowe i metody wnioskowania statystycznego.

Wyniki: Leki W grupie badanej częstość występowania hiperleptynemii u stewardess (22.2%) była istotnie większa niż w grupie kontrolnej (6.1%), p<0,05. Nie stwierdzono jednak istotnych statystycznie różnic pomiędzy podgrupami Ia i Ib. Nieprawidłową tolerancję glukozy (IGT) stwierdzono u 10% grupy badanej i 5% grupy kontrolnej. Hiperinsulinemia występowała nieistotnie częściej w grupie badanej, zwłaszcza u tych stewardess, które latają na lotach długodystansowych, pracują rzadziej i mają dłuższy staż pracy.

Wnioski: Specyficzne warunki pracy stewardess, a zwłaszcza jej zmianowy charakter wpływają na częstsze występowanie hiperleptynemii. Biorąc pod uwagę fakt, że nieprawidłowa tolerancja glukozy występuje 3-krotnie częściej u stewardess, należy przyjąć że ta grupa zawodowa jest w grupie ryzyka występowania cukrzycy w przyszłości.

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Introduction

Shift work has become an integral aspect of today's society. It is estimated that approximately 20% of workers worldwide engage in shift work [1]. The presence of light at night, decreased physical activity, nocturnal eating habits, and frequent changes in the circadian rhythm disrupt the synchronization of natural body rhythms, leading to disturbances in physiological functions [2]. Epidemiological studies indicate that shift work can influence the development of cardiovascular diseases, carbohydrate metabolism disorders, and obesity [3].

Short sleep duration (defined as ≤ 6 hours of sleep per day) and other sleep disorders related to shift work negatively impact the hormonal profile [4]. Limited sleep has metabolic and endocrinological consequences, including reduced glucose tolerance and insulin sensitivity, increased nighttime cortisol levels, elevated levels of leptin, and excessive hunger and increased appetite [5,6,7].

Leptin is a hormone produced by adipocytes. Its concentration in blood is relative to the human circadian rhythm, with the highest levels occurring from midnight to early morning [8]. Research results regarding the effect of sleep deprivation on leptin levels are contradictory [9]. Due to the different distribution of body fat, leptin levels are 2-3 times higher in women than in men. This is also because women have higher estrogen levels, and estrogen increases leptin synthesis, while androgens inhibit it [10]. Leptin concentration also depends on the phase of the menstrual cycle and the quality and frequency of meal intake. Nighttime eating increases leptin's secretion. High levels of this hormone are associated with an increased risk of diabetes, liver diseases, and cardiovascular diseases [11].

The work of flight attendants is associated with exposure to disturbances in the circadian rhythm, sleep deficiency or deprivation, and irregular meal consumption. These factors may lead to disrupted leptin secretion and an increased risk of carbohydrate metabolism disorders. To our best knowledge, no previous research has discussed the leptin levels among stewardesses. Therefore, the aim of this study was to determine the levels of leptin, glucose, and insulin patterns and to seek factors potentially influencing the secretion of leptin, glucose, and insulin in female flight attendants working within one time zone (more take-offs and more landings) as well as on long-distance flights.

Material and Methods

STUDY DESIGN The cross-sectional study involved 103 Polish women aged between 23 and 46. These women were qualified for the study by the Department of Obstetrics and Gynecology, Medical University of Warsaw. The examinations took place at the Department of Gynecological Endocrinology, Medical University of Warsaw, Poland, during the years 2013–2016. Notification about the planned study was also provided to the trade unions of LOT Polish Airlines and EUROLOT Polish Airlines. Exclusion criteria for both the study and control groups included the use of hormonal drugs (including contraceptives) up to 6 months prior to the study, the use of drugs inducing the activity of hepatic enzymes which can affect human hormonal balance, a history of chronic renal insufficiency and liver cirrhosis, and the diagnosis of menopause in women over 40, according to the WHO criteria. Polish trade unions represent over five hundred flight attendants. Out of seventy-four flight attendants who responded to the letter of invitation, forty-three qualified for the study. All patients provided written informed consent for study participation. The study group (I) comprised female flight attendants flying within one time zone as well as those serving on long-distance flights. The study included female flight attendants who consented to participate, were of reproductive age, and worked under the night shift system. The control group (II) consisted of 60 women of reproductive age seeking medical assistance due to marital infertility, with the male factor identified as responsible for conception problems during the diagnostic process. These women worked full-time (160 hours per month) as clerks in the public sector, without engaging in night shift work and reporting no exposure to excessive work-related stress.

SAMPLE COLLECTION AND ANALYSIS The examination adhered to the protocol for diagnosing hormonal disorders at the Department of Gynecological Endocrinology, Medical University of Warsaw. The patients were not examined directly after night shifts. The study group was divided into two subgroups: Group Ia (n = 17) consisted of female flight attendants flying within one time zone, and Group Ib (n = 26) consisted of female flight attendants working on long-distance flights. We conducted oral glucose and insulin tolerance tests, along with assessing leptin concentrations in blood samples collected from the antecubital vein. The evaluation encompassed various factors: age, the body mass index (BMI), menstrual cycle regularity, length of service (in years) , flying frequency, leptin concentration, oral glucose tolerance test (OGTT), insulin pattern, and HOMA-IR. Women with fasting glucose levels of 100-125 mg/dl and glucose levels after 2 hours of 140-200 mg/dl, according to the PTD criteria, were diagnosed with prediabetes IGF [12]. Insulin resistance was diagnosed in patients with a HOMA-IR index ≥ 2.5 [13]. Hyperinsulinemia was defined as fasting hyperinsulinemia (≥15 mIU/ml) or hyperinsulinemia after glucose provocation (≥80 mIU/ml) [14]. The assessment did not encompass smoking, alcohol consumption, physical activity, or dietary habits. The study design is presented in Figure 1. Menstrual cycles of 25–35 days were considered regular. Flying frequency was expressed in terms of monthly flying hours. To assess the impact of flying frequency on the development of hormonal disturbances, the study group of the female flight attendants was divided into two subgroups: those working fewer than 60 hours per month and those working 60 or more hours per month. To evaluate the influence of the length of work on the development of hormonal disturbances, the study group of the female flight attendants was divided into two subgroups: those working less than 15 years and those working 15 or more years.

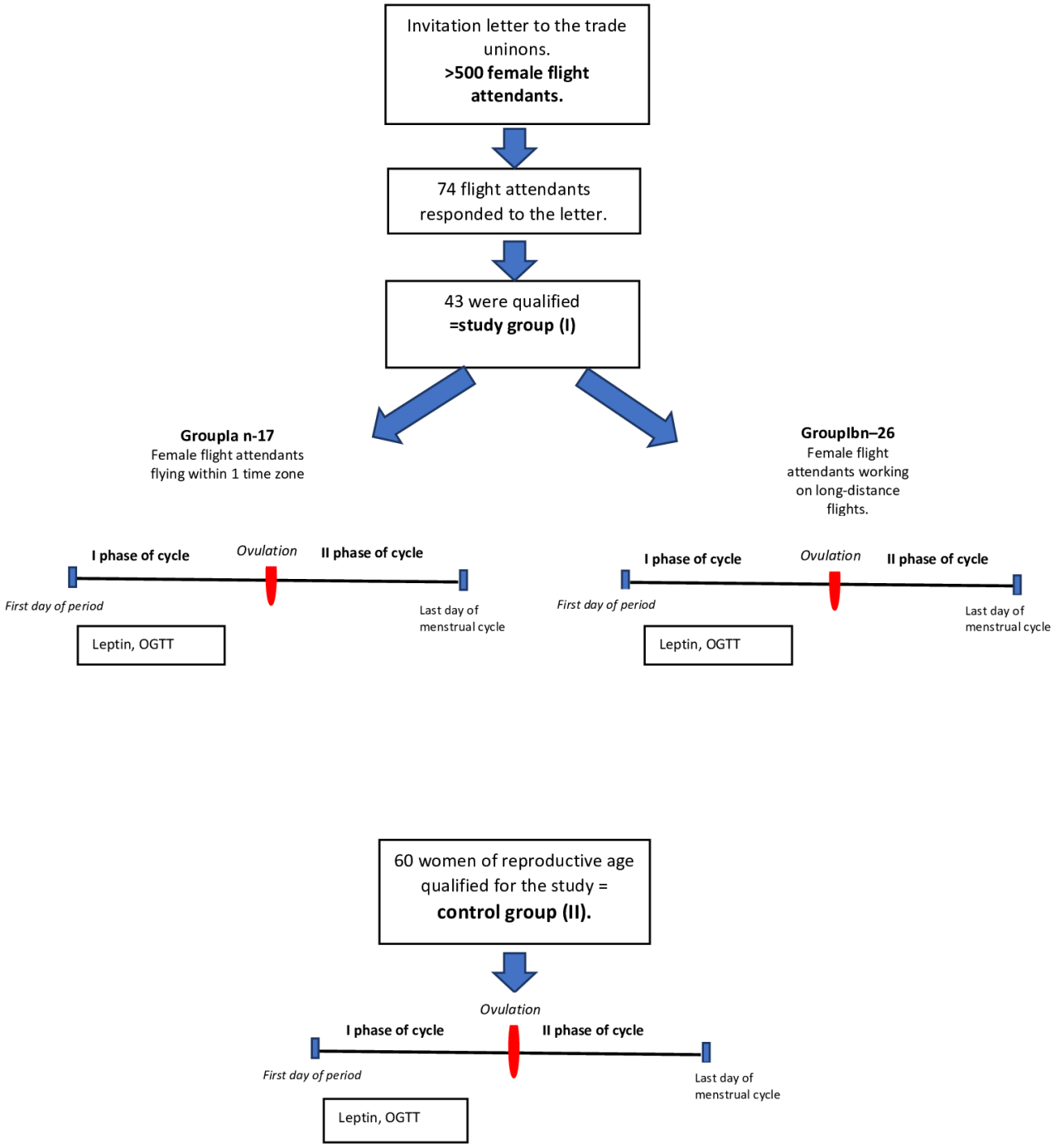

Figure 1 Study design.

ETHICS An informed consent was obtained from all the subjects before participating in the study. Approval for this study was granted by the Medical University of Warsaw, Ethics Board (KB/254/2013, November 12th, 2013).

STATISTICAL ANALYSIS Descriptive methods and inferential statistical methods were employed to compile the data. The randomness of the study sample was examined in terms of the age and length of work of the patients. To this end, a test of series was applied to examine the hypothesis that the way in which patients were selected could be deemed random. Knowing the order in which the patients registered for the study, the randomness of the sample in terms of age and length of work was confirmed. For qualitative features, the following

characteristics were calculated: arithmetic mean (x), median (Me), standard deviation (SD), and coefficient of variation (v%). The chi-square independence test was applied to compare the frequency of the occurrence of individual varieties of features in the study groups and in the subgroups. When expected numbers were less than 5, Yates correction was used in the chi -square test calculation. Prior to the comparison of mean values in the study groups and subgroups, the conformity of the distributions of the analyzed measurable variables with the normal distribution was checked using the Shapiro-Wilk test. Since the distributions of most analyzed variables significantly differed from normal, the comparison of the mean values was chosen to be made with the help of the non-parametric test, rather than the parametric test. As the samples were independent, the Mann-Whitney test was used to compare the mean values. To study the correlation between the measurable variables, the rank correlation coefficient was applied due to distributions significantly different from the normal distribution. The differences between mean values (or frequencies) were found statistically significant when the calculated value of a relevant test was equal or higher than the critical value from relevant tables, with an adequate number of the degrees of freedom and the probability of error $p<0.05$.

Results

Table 1 presents the characteristics of the study group and the control group, including the subgroups of women flying within one time zone and women serving long-distance flights. In the control group (II), the mean age of respondents was 34.0 ± 4.09 years. Women in the study group (I) ranged in age from 25 to 43, with an average age of 34.7 ± 4.41 years. The length of work in the study group ranged from 6 to 25 years, with an average of 14.3 ± 5.06 years. Half of the women in the study group had worked for 15 or more years. The women in the study group spent 47 to 85 hours flying per month, with an average of 64.6 ± 7.89 hours, and half of them spent 65 or more hours flying per month.

Leptin secretion was examined in both the control group and the study groups. The mean concentration of this hormone in the control group was 13.3 ± 8.56 ng/ml. The range of leptin concentrations in this group was between 2.9 and 41.0 ng/ml. In the study group, the range of leptin concentrations fluctuated between 5.3 and 150.2 ng/ml, with an average of 16.1 ± 23.6 ng/ml. There were no significant differences in the mean leptin concentration between the study group and the control group, as well as between subgroups Ia and Ib (10.9 ng/ml vs. 19.4 ng/ml; $p > 0.05$), subgroup Ia and control group (10.9 ng/ml vs. 13.3 ng/ml; $p > 0.05$), and subgroup Ib and control group (19.4 ng/ml vs. 13.3 ng/ml; $p > 0.05$). The differences were non-significant, possibly due to the very high variability of leptin concentrations in subgroup Ib (coefficient of variation 153.4%). Analyzing the relationship between leptin secretion and length of work, no statistically significant differences were found. Female flight attendants working longer had a higher mean leptin concentration compared to those with shorter work experience (11.6 ± 4.5 ng/ml vs. 20.2 ± 32.1 ng/ml; $p = 0.384$). The relationship between leptin secretion and the number of flying hours was also examined. Although leptin concentration was higher in women spending more than 60 hours per month flying, no statistically significant difference was found (19.3 ± 29.9 ng/ml vs. 11.2 ± 5.38 ng/ml; $p = 0.384$).

In the study group, the prevalence of hyperleptinemia among flight attendants (22.2%) was significantly higher than in the control group (6.1%), $p<0.05$. When comparing the frequency of hyperleptinemia between subgroups Ia and Ib, no statistically significant difference was found, although hyperleptinemia occurred much more frequently in subgroup Ib than in subgroup Ia (31.8% vs. 7.1%; $p=0.118$). There was no statistically significant relationship between the length of work and leptin secretion, as well as between the frequency of flying and leptin secretion. The calculated rank correlation coefficients were very close to zero both in the entire study group and in subgroups Ia and Ib ($p > 0.05$).

Variable	Control group (II) (N=60)			Studygroup (I) (N=43)				Group Ia (N=17)			Group Ib (N=26)			
	Min	Max	M±SD	Min	Max	M±SD	p	Min	Max	M±SD	Min	Max	M±SD	p
Age (years)	23	46	34.0 ± 4.09	25	43	34.7 ± 4.41	0.203	26	43	34.1 ± 4.26	25	40	35.2 ± 4.53	0.219
BMI (kg/m^2)	17.5	37	22.7 ± 3.78	17.5	29.0	22.4 ± 2.71	0.995	17.5	28	21.7 ± 2.67	19	29	22.8 ± 2.71	0.28
Seniority (years)				6	25	14.3 ± 5.06		6	18	13.0 ± 4.23	6	25	15.2 ± 5.44	0.084
Time of work in air (h/month)				47	85	64.6 ± 7.89		47	70	59.5 ± 6.80	55	85	67.9 ± 6.81	0.001

Table 1 The characteristics of the study group and control group, including the subgroups of women flying within one time zone and women serving long-distance flights. Time of work in air was significantly different between groups Ia and Ib. *Bolded is p<0.001. Control group (II) – 60 women of reproductive age who sought medical assistance due to marital infertility in whom the male factor was found to be responsible for problems with conception in the course of the diagnostic process; Study group (I) – 43 female flight attendants; Group Ia – 17 female flight attendants flying within one time zone; Group Ib – 26 female flight attendants working on long-distance flights.*

Regarding glucose secretion in flight attendants, in the Oral Glucose Tolerance Test (OGTT), the mean fasting glucose concentration was 83.6 ± 5.13 mg/dl, after the first hour it was 138.7 ± 41.0 mg/dl, and after the second hour it was 98.7 ± 31.2 mg/dl. In the study group, the range of fasting glucose concentrations in OGTT was between 74.0 and 98.0 mg/dl, after the first hour it ranged from 57.0 and 261.0 mg/dl, and after the second hour it ranged from 40 and 174 mg/dl. In subgroup Ia, the mean fasting glucose concentration was 84.9 ± 6.77 mg/dl, after the first hour it was 141.2 ± 49.7 mg/dl, and after the second hour it was 98.1 ± 37.2 mg/dl. In subgroup Ib, the OGTT profile was as follows: fasting - 82.7 ± 3.47 mg/dl, after the first hour - 137.1 ± 35.4 mg/dl, and after the second hour - 99.1 ± 27.5 mg/dl. In the control group, the mean fasting glucose concentration was 83.8 ± 5.91 mg/dl, after the first hour it was 135.4 ± 34.3 mg/dl, and after the second hour it was 101.5 ± 21.2 mg/dl. No significant differences were found between the study groups.

Based on the OGTT results, Impaired Glucose Tolerance (IGT) was found in 10% of the study group and 5% of women in the control group. Despite the twice higher frequency of abnormal glucose tolerance in the study group, the difference was not statistically significant (p = 0.355). The prevalence of IGT was compared between subgroups Ia and Ib. Impaired Glucose Tolerance occurred much more frequently in women flying within one time zone (19% vs. 4%, p=0.145). According to the PTD criteria, no cases of diabetes were diagnosed based on the OGTT results.

Regarding insulin secretion in flight attendants, in the OGTT, the mean fasting insulin concentration was 4.86 ± 1.58 mIU/l, after the first hour it was 46.8 ± 30.4 mIU/l, and after the second hour it was 30.4 ± 23.3 mIU/l. In the study group, the range of fasting insulin concentrations in OGTT was between 2.6 and 9.2 mIU/l, after the first hour it ranged from 11.1 and 170.2 mIU/l, and after the second hour it ranged from 3.5 and 157.6 mIU/l. In subgroup Ia, the mean fasting insulin concentration was 5.33 ± 1.63 mIU/l, after the first hour it was 45.8 ± 30.1 mIU/l, and after the second hour it was 32.7 ± 34.3 mIU/l. In subgroup Ib, the insulin curve was as follows: fasting - 4.56 ± 1.5 mIU/l, after the first hour - 47.7 ± 25.0 mIU/l, and after the second hour - 28.9 ± 12.6 mIU/l. In the control group, the mean fasting insulin concentration was 5.28 ± 1.76 mIU/l, after the first hour it was 44.8 ± 27.8 mIU/l, and after the second hour it was 32.6 ± 20.9 mIU/l. No significant differences were found between the study groups. Based on the OGTT results, the Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) was calculated, and no cases of insulin resistance were found in both the study and control groups.

Hyperinsulinemia was found in 6 flight attendants (14%) and 10 patients from the control group (18%), p > 0.05. Hyperinsulinemia occurred slightly more frequently in women flying on long-distance flights (15% vs. 12%, p=0.118) and those working less than 60 hours per month (p=0.184) and more than 15 years in the profession (p=0.068).

Discussion

Hyperleptinemia, which is an elevated level of leptin in the blood, is undoubtedly related to increased body mass [15]. In our study, 83% of patients in the control group and 88% of the examined flight attendants had a normal body weight, while the prevalence of hyperleptinemia in flight attendants was 22.2% significantly higher than in the control group (6.1%). Koo et al. examined 254 men and women in southern Taiwan and found a significant, leptin-independent association between short sleep duration and the presence of hyperleptinemia in women (OR = 4.98, 95% CI = 0.80-42.40) [16]. Epidemiological studies reveal a causal relationship between reduced sleep/shift work and metabolic disorders [17,18]. Lack of sleep can result in an additional daily energy intake of about 350–500 kcal and an increase in calorie intake from snacks, which may lead to hyperleptinemia [19].

In this study, we also demonstrated higher mean leptin concentrations in flight attendants compared to the control group (16.1 ng/ml vs. 13.3 ng/ml). There are very few studies evaluating the correlation between shift work and leptin levels. Molzof et al. observed a similar relationship when examining leptin levels in nurses working in a hospital in the USA. The study group consisted of 18 women, 10 of whom worked night shifts, and 8 only worked during the day. They found that the mean leptin concentration in women working night shifts was 7.4 ng/mL higher than those working only during the day, and this difference was significant (p = 0.03) [11]. There are also studies showing lower mean leptin concentrations in shift workers, but a noticeable differentiating factor between studies with conflicting conclusions to ours is the length of work experience [20]. Chronic exposure to shift work generates higher leptin concentrations, which confirms the observed relationship in our study, where women with work experience exceeding 15 years had higher leptin concentrations than flight attendants with shorter work experience.

Hyperleptinemia contributes to carbohydrate metabolism disorders [21]; therefore, in the study, an OGTT was conducted. According to the WHO criteria, no cases of diabetes were diagnosed in either study groups. However, we did find a three times more frequent occurrence of Impaired Glucose Tolerance (IGT) in flight attendants than in the control group. Similar results were obtained by Oyama et al. who examined IGT in 6413 men employed in three different work systems: dayworkers, shift workers, and 2-shift workers, considering BMI values. IGT was defined as HbA1c > 5.9%, and they found that the risk of developing glucose tolerance disorders was significantly elevated in both 2-shift and 3-shift workers. This risk was also observed in workers with normal body weight [22].

Melatonin has been recognized as a key factor influencing insulin synthesis, secretion, and action. Additionally, melatonin's action regulates the expression of glucose transporter type 4 (GLUT 4) and induces insulin receptor phosphorylation.

Therefore, reduced melatonin levels may be associated with increased insulin resistance. Hence, some researchers suggest melatonin supplementation for shift workers [23]. In our study, we did not find insulin resistance in either the study or control group, but hyperinsulinemia occurred slightly more frequently in flight attendants, especially in those flying on long-distance flights, working less frequently, and having longer work experience. Sadeghniiat-Haghighi et al. calculated HOMA-IR in 453 professional drivers, dividing them into three groups: day workers, night workers, and early morning shift workers. The researchers showed that shift work could be a significant risk factor for the development of insulin resistance [24]. Similar results were obtained by researchers in a large study conducted on a European population of 1,351 workers. They showed that shift workers had higher fasting insulin values compared to day workers, contributing to a 1.5-fold increased risk of metabolic syndrome in combination with other identified risk factors [25].

Conclusions

The specific working conditions of flight attendants, especially their nature of shift work, contribute to a higher prevalence of hyperleptinemia. Considering the fact that Impaired Glucose Tolerance occurs twice as frequently in flight attendants, it is reasonable to assume that this occupational group is at risk of developing diabetes in the future. A larger study group would also be necessary to ensure a representative distribution of the population and allow for the generalization and transferability of the results.

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