sustainability

MDPI

Article

Exploring the Impact of Obesity and Insomnia on Work Productivity: Insights for Occupational Health and Sustainability in the Workplace

Ginevra Malta †, **Fulvio Plescia** † and **Emanuele Cannizzaro** *

Department of Health Promotion, Mother and Childcare, Internal Medicine and Medical Specialties (PROMISE), 90127 Palermo, Italy; ginevra.malta@unipa.it (G.M.); fulvio.plescia@unipa.it (F.P.)
* Correspondence: emanuele.cannizzaro@unipa.it
† These authors contributed equally to this work.

Abstract: Background: The prevalence of obesity and sleep disorders within the Italian workforce mirrors a global trend where sedentary lifestyles, poor eating habits, and elevated stress levels significantly contribute to these health issues. These conditions have profound economic implications, including rising healthcare costs and diminished productivity due to absenteeism and presenteeism, adversely affecting organizational sustainability and employee well-being. Addressing these problems necessitates a holistic approach that integrates individual health interventions, workplace policies, and broader societal changes to promote healthy lifestyles. This cross-sectional study examines the influence of obesity and insomnia, both individually and combined, on work productivity within the context of occupational health and sustainability. **Materials and Methods**: A cross-sectional analysis was conducted with 397 participants from various professions over a six-month period. Self-reported work productivity impairments were assessed using the Work Productivity and Activity Impairment (WPAI) questionnaire. Body Mass Index (BMI) and Insomnia Severity Index (ISI) scores were utilized to evaluate obesity and insomnia levels, respectively. **Results**: Statistical analyses revealed a significant association of higher BMI and ISI scores with reduced work productivity. Both obesity and insomnia independently and synergistically contributed to productivity losses, with obesity exerting a more substantial effect. These findings indicate that obesity and insomnia increase presenteeism, thereby negatively impacting organizational performance and workplace sustainability. **Conclusions**: Our study underscores the critical impact of obesity and insomnia on work productivity and highlights the necessity of addressing these health issues not only for individual well-being but also for organizational sustainability. Integrating targeted health management strategies within workplaces to address these conditions can enhance productivity, improve employee well-being, and promote occupational health and safety. These interventions align with the current concept of sustainable work and are essential steps toward achieving sustainability in the workplace.

Keywords: obesity; insomnia; work productivity; presenteeism; workplace sustainability

check for updates

Academic Editors: Tianan Yang, Jianwei Deng and Ran Liu

Received: 1 December 2024
Revised: 27 December 2024
Accepted: 29 December 2024
Published: 8 January 2025

Citation: Malta, G.; Plescia, F.; Cannizzaro, E. Exploring the Impact of Obesity and Insomnia on Work Productivity: Insights for Occupational Health and Sustainability in the Workplace. *Sustainability* **2025**, *17*, 424. https://doi.org/10.3390/su17020424

1. Introduction

Productivity, in economic terms, is defined as the ratio of value added in volume to one or more factors of production used to generate it. It measures the efficiency with which the primary factors—labor and capital—are employed in the production process. According to this definition, labor productivity can be expressed as the ratio of value added to total hours worked [1]. "Hours worked" refer to the time during which a worker is present at work, at the employer's disposal, and engaged in their activities or duties. Therefore, absences, whether due to holidays or illness, can be considered a measure of non-productivity [2].

Productivity in the workplace is an outcome that holds significance not only in the economic sphere but also in health, serving as an indicator of an individual's health status [3]. Numerous factors can influence productivity—both extrinsic to the individual (i.e., linked to the work environment) and intrinsic (i.e., related to physical and psychological factors) [4]. Intrinsic factors include workers' psychological and physical conditions, such as metabolic conditions [5], sleep–wake rhythms [6], and psychological alterations, whether work-related or not [7].

Among metabolic conditions that impair daily and working life, obesity plays a central role. An individual is classified as obese if they have a body mass index (BMI) greater than 30, calculated by dividing their weight in kilograms by the square of their height in meters [8].

Obesity can limit an individual's ability to perform certain work tasks, although there is no definitive list of tasks that a person with obesity cannot perform absolutely. Limitations depend on the degree of obesity, general health, and other specific considerations [9]. Some limitations that an individual with obesity may experience in the workplace include performing physically demanding work (obesity may affect physical endurance and mobility, making it difficult to perform tasks requiring intense physical effort or involving frequent and repetitive movements), working in confined or restricted environments (as movement may be more challenging), working at heights (tasks that require being on platforms or ladders may be dangerous for those with balance problems or limited mobility) [10], high-responsibility jobs (since obesity may affect general health and the ability to handle stress, potentially limiting one's capacity to manage tasks with high emotional pressure) [11], and jobs with specific uniform or dress requirements that may not comfortably fit an individual with obesity [12].

It is important to note that laws prohibiting discrimination based on race, gender, age, physical and/or socio-cultural differences, and disability also protect obese individuals from workplace discrimination [13].

The European Court, drawing upon Directive 2000/78/EC concerning the prohibition of discrimination on the grounds of disability, expressed, in judgment C-354/13 of 2014, that obesity can constitute a genuine obstacle to the full performance of work duties [14]. The Organization for Economic Co-operation and Development (OECD) has also emphasized obesity as a factor that not only leads to productivity losses but also contributes significantly to management costs [15]. Obesity and, more specifically, the nutritional status related to or predisposing individuals to chronic diseases, is a problem that demands continuous attention in both youth and adults [16]. To formulate and implement effective interventions for the prevention and treatment of diseases associated with a high body mass index (BMI), up-to-date quantitative global data are essential [17]. Despite advancements in clinical and scientific knowledge, which have enhanced our understanding of the pathogenesis of obesity and improved patient management, the prevalence of high BMI values has continued to show an increasing trend in recent decades [18].

Sleep disorders are among the well-known sequelae that obese individuals may experience, a factor on which occupational medicine focuses its attention—particularly on how sleep, circadian rhythms, and sleep disturbances affect workplace safety, general health, and productivity [19]. Individuals with sleep disorders have a significantly higher risk of cardiovascular diseases such as hypertension and cardiac and cerebral ischemic episodes, with effects that may lead to or aggravate various neurological or psychiatric conditions, including dementia, anxiety, depression, and post-traumatic stress disorder (PTSD) [20,21].

In addition to metabolic comorbidities, certain specific work-related tasks seem to influence the onset of pathologies associated with disruptions in the sleep–wake cycle [21–23] and may also precisely favor the onset of obesity [24]. The pathogenetic mechanism appears to be related to factors such as workplace organization and environment, along with conditions that contribute to increased stress levels. Particularly noteworthy are occupations that involve night shifts (requiring at least three hours of work between midnight and 5 a.m.) [25], which seem to negatively influence an individual's functional adaptation to the circadian rhythm and play a central role in the genesis of various pathologies [26].

Recognizing the interconnectedness of obesity and sleep disorders, the objective of this study was to analyze the impact of these conditions on work productivity, both individually and in their interrelation.

The prevalence of obesity and sleep disorders within the Italian workforce reflects a broader global trend where sedentary lifestyles, unhealthy dietary patterns, and stress significantly contribute to these health challenges [27]. Prior research has established links between these conditions and workplace outcomes; however, studies predominantly focus on their individual effects rather than their combined impact on work productivity. This gap is particularly critical within the context of sustainability, where promoting occupational health is key to long-term organizational performance [28]. Addressing these conditions collectively can provide novel insights into strategies for improving workplace productivity and reducing economic costs. This study explores these synergistic effects, emphasizing the need for integrated interventions in workplace health promotion.

2. Materials and Methods

2.1. Sample

Data were collected from January 2023 to December 2023. Participation was voluntary, and all participants were informed about the purpose of the research, providing informed consent prior to participation. To ensure privacy and anonymity, respondents were instructed not to mention their name or company name.

The study was conducted using an anonymous questionnaire that participants filled out while waiting for their mandatory health surveillance visit—periodic examinations required for continued employment—which was carried out immediately after completing the questionnaire at a private occupational medicine clinic located in Palermo. The subjects were examined by physicians specialized in occupational medicine.

The companies, which were informed of the initiative and the purpose of the research, actively participated by providing each worker, regardless of their participation in the study, with a summary of the days of sick leave or holidays taken in the last six months.

The volunteers were employed individuals across occupational sectors with varying physical and cognitive demands, including food service workers, drivers, video display terminal operators, clerical workers, and factory workers. Given the focus of this study on productivity loss influenced by physical and mental health, the sample primarily targeted roles that involve physical effort and cognitive engagement. This criterion ensured relevance to our research objectives. While generalization to sedentary occupations may be limited, this targeted approach provides focused insights into high-risk job categories where obesity and insomnia could have more pronounced effects.

The inclusion criteria for analyzing the questionnaires were current employment status, legality of employment in terms of contract, and a contract duration of at least one year.

Exclusion criteria were individuals not yet employed, individuals who declared not having a regular contract, night workers, those with seasonal contracts (quarterly), subjects deemed fit for work with restrictions or prescriptions, individuals with alcohol or drug abuse issues, and those attending preventive visits.

As the data were obtained in a completely anonymous manner, exclusively through a self-administered questionnaire with informed consent given at the time of collection, the study, in accordance with the World Health Organization's provisions on scientific research, did not require the approval of local ethics committees [29].

Out of the total number of completed questionnaires (*n* = 416), a sample of 397 subjects was selected, belonging to different production activities, of both genders (female: 190; male: 207), and aged between 27 and 64.

Nineteen questionnaires were excluded because they were incomplete or had unreliable data (e.g., identical answers to every question). Specifically, 12 questionnaires reported weight-related data that deviated by at least 5 kg from the actual figure measured during the visit and were found to be incomplete in all questions, while 7 questionnaires contained correct anthropometric data but did not have all answers completed. All other questionnaires had anthropometric data corresponding to those measured during the visit and were complete in every part.

2.2. Tools

The questionnaires described below were provided in a single format divided into three sections: anamnestic and socio-demographic data (including gender; age; height; weight; and risk factors such as comorbidities/medications, smoking, and alcohol consumption), questions on sleep disorders, and questions on work activity.

2.2.1. Nutritional Status/Obesity

To assess the nutritional status of the participants, the body mass index (BMI) was calculated using the self-reported data from the anamnestic section of the questionnaire. BMI was determined by dividing weight in kilograms by the square of height in meters. This value categorizes individuals according to their body weight status as follows: severely underweight (BMI < 16.5), underweight (BMI between 16.00 and 18.49), normal weight (BMI between 18.5 and 24.99), overweight (BMI between 25.00 and 29.99), obesity class I (BMI between 30.00 and 34.99), obesity class II (BMI between 35.00 and 39.99), and obesity class III (BMI $\geq$ 40.00) [30].

2.2.2. Sleep Disorders

Among sleep disorders, insomnia was selected for analysis, as it is the most common in the adult population and the most extensively studied in the literature.

For the assessment of sleep disorders, the Insomnia Severity Index (ISI) questionnaire was utilized. The ISI combines diagnostic criteria for insomnia drawn from the *Diagnostic and Statistical Manual of Mental Disorders* [31] and the *International Classification of Diseases, 10th Edition* [32] and includes considerations of the use of sleep-promoting products, both prescribed and over-the-counter.

The ISI questionnaire [33], modified to reflect the past six months, was administered to participants. This instrument assesses parameters such as the severity of insomnia problems, difficulties with sleep maintenance and early morning awakenings, dissatisfaction with sleep, interference of sleep difficulties with daily functioning, perception of sleep problems by others, and distress caused by poor or unsatisfactory sleep. It consists of seven questions, each with five response options scored from 0 (no problem) to 4 (very severe problem).

Based on the ISI responses, participants were categorized into four groups: No Clinically Significant Insomnia (NCSI; scores 0–7), Subthreshold (mild) Insomnia (SI; scores 8–14), Moderate Clinical Insomnia (MCI; scores 15–21), and Severe Clinical Insomnia (SCI; scores 22–28) [34].

2.2.3. Work Productivity

To investigate the impact of illness on productivity, we employed the Work Productivity and Activity Impairment (WPAI) questionnaire [35], an instrument designed to measure impairments in both paid and unpaid work. The WPAI assesses absenteeism, presenteeism, and impairment in unpaid activities due to health problems over the past seven days [36]. In alignment with methodologies adopted in other studies utilizing the same questionnaire [37,38], the reference period was extended from '7 days' to '6 months' to broaden the assessment scope and account for 'sickness absences' reported by workers attributable to the illnesses under examination. To ensure that this modification did not compromise the validity of the questionnaire, control tests were conducted by comparing the proportionality of the results [39].

The WPAI consists of six questions which, when the respondent is a wage earner (question 1), enable the measurement of the number of work hours missed due to health reasons (question 2), hours missed for other reasons (question 3), actual hours worked (question 4), the extent to which health problems affected productivity while at work (question 5), and impairment of activities of daily living (question 6).

To assist workers in accurately completing the questionnaire, the company provided a conversion table to translate days into hours, which included values for weekly working hours and total working hours over the past six months, along with the number of any days of absence taken, distinguished between 'sickness' and 'other reasons'. For respondents who, due to various difficulties—often related to their level of education—completed the questionnaire by indicating days instead of hours, the authors performed the conversion into hours.

Based on the responses obtained from the questionnaire, we calculated several metrics to estimate productivity losses, expressed as percentages. Higher values indicate a greater percentage of time lost at work, reflecting lower productivity or reduced activity levels:

- Absenteeism: $[Q2/(Q2 + Q4)] \times 100$;
- Presenteeism: $Q5/10 \times 100$;
- Work productivity reduction: $Q2/(Q2 + Q4) + [(1 - Q2/(Q2 + Q4)) \times (Q5/10)] \times 100$;
- Impairment of activities of daily living: $Q6/10 \times 100$

Furthermore, to gain a more comprehensive understanding of the extent of the problem, we took into account the number of sick days taken by the workers, as reported in the relevant section of the questionnaire.

2.3. Data Analysis

Data analysis was performed using the GraphPad Prism 10.0 statistical software package (GraphPad Company, San Diego, CA, USA).

A database was established containing the collected information, organized into the following columns: subject number, gender, age, weight, height, BMI, ISI score, responses to the WPAI questionnaire, number of sick days taken, absenteeism, presenteeism, reduced work productivity, and impairment in activities of daily living (ADL).

Initially, simple linear regression models were employed, alternately using BMI and ISI as independent variables and work productivity reduction (WPR) as the dependent variable to analyze the impact of each variable on labor productivity. Furthermore, to assess the degree of correlation between BMI, ISI, and WPR, Pearson correlation coefficients were calculated. The same parameters were also analyzed with consideration of gender and age.

Subsequently, a multiple linear regression analysis was conducted to evaluate the joint impact of BMI and ISI variables on WPR.

To analyze differences in activity reduction among the various groups identified based on BMI and ISI scores, a one-way repeated measures ANOVA was performed, followed by Tukey's post hoc test with an alpha level of 0.05.

Mutually exclusive groups were created based on body mass index and the presence of insomnia. Specifically, the following reference ranges were considered:

- BMI > 30: obese subjects;
- BMI between 25.00 and 29.99: overweight subjects;
- BMI < 24.99: normal-weight subjects;
- ISI score $\geq$ 8: subjects with insomnia;
- ISI score $\leq$ 7: subjects without insomnia.

For each group, work productivity reduction was assessed for both genders combined and separately for males and females.

3. Results

A total of 397 individuals participated in the study, comprising 207 males (M, 52.14%) and 190 females (F, 47.86%). The mean age of the participants was 46.02 years (range: 27–64 years; standard deviation [SD]: 9.13). Other socio-demographic characteristics are presented in Table 1.

Table 1. Socio-demographic characteristics of final study population.

Age	**Mean Age**	**Min**	**Max**
	45.5	27	64
Gender		***n***	**%**
Male (M)		207	52.14
Female (F)		190	47.85
Smoking Status			
Smoker		212	53.40
Non-Smoker		185	46.59
Alcohol Consumption			
Occasional Consumer		192	48.36
Non-Consumer		205	51.63
Comorbidities/Medications			
Hypertension		107	26.95
Diabetes		106	26.70
Thyroid Disease		67	16.87
None		117	29.47
Occupation			
Food Service Workers		65	16.37
Drivers		61	15.36
Video Screeners		60	15.11
Employees		75	18.89
Construction Workers		66	16.62
Farmers		70	17.63

The mean body mass index (BMI) was 25.25 (SD 2.95), with values ranging from 18.43 to 34.34. A total of 31 subjects had a BMI greater than 30, representing approximately 7.80% of the total sample; 179 participants (45.09%) had a BMI between 25 and 30; and 187 participants (47.10%) had a BMI of less than 25.

The mean Insomnia Severity Index (ISI) score was 5.19 (SD 5.04), with scores ranging from 0 to 25; 103 subjects had an ISI score greater than 7.

Analysis of the results obtained from the WPAI scores revealed that the entire sample missed 13,939 h of work due to illness (males: 7755 h (55.53%); females: 6184 h (44.46%)), representing 2.92% of the total working hours to be completed.

The average number of sick days taken was 4.69 days (range: 0–12.30 days; SD: 3.03), with absenteeism representing 2.91% of total hours worked.

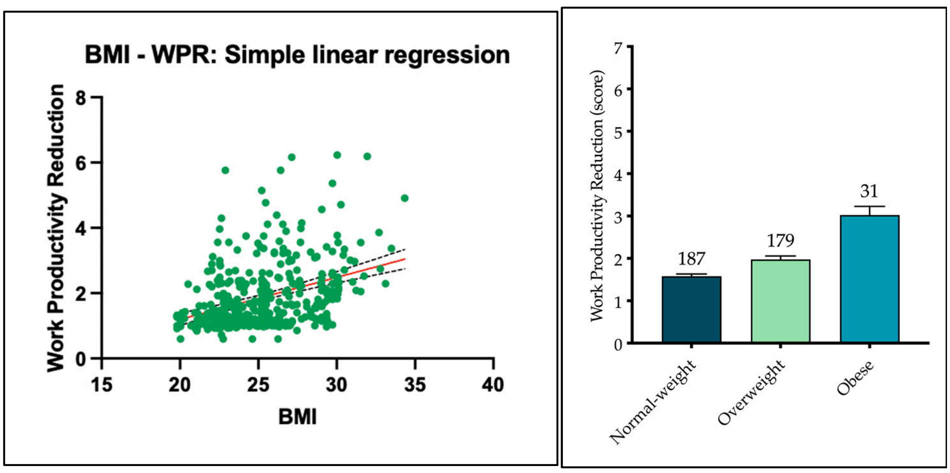
The calculated absenteeism rate over the last six months of employment was 2.98%. The overall reduction in labor productivity for the entire sample was 1.74%. Detailed comparisons of these variables between groups are presented in Table 2.

Table 2. Absenteeism rates and work productivity reduction in groups stratified by BMI and ISI-scores.

Group	*n*	Absenteeism %	Work Productivity Reduction %
Subjects with insomnia (ISI score $\geq$ 8)			
Obese	21	3.50	2.38
Overweight	58	2.80	1.64
Normal weight	24	3.09	1.71
Subjects without insomnia (ISI Score $\leq$ 7)			
Obese without insomnia	10	3.31	2.27
Overweight without insomnia	121	2.81	1.67
Normal weight without insomnia	163	3.04	1.70

3.1. Impact of BMI on Work Productivity Reduction

To specifically examine the impact of body mass index (BMI) on work productivity reduction (WPR), a simple linear regression analysis was conducted. The analysis yielded an R-squared value of 0.145, a BMI coefficient of 0.1288, and a *p*-value < 0.001, indicating a statistically significant association between BMI and WPR. Furthermore, the Pearson correlation coefficient between BMI and WPR was 0.38, with a highly significant *p*-value (approximately 4.07×10^{-15}), demonstrating a moderate positive correlation between the two variables (Figure 1).



(**A**) (**B**)

Figure 1. (**A**) Linear regression graph and (**B**) bar graph showing the relationship between BMI and WPR; in the bar graph, subjects are divided into normal weight, overweight, and obese.

Figure 2 shows a general trend indicating that higher BMI values are associated with increased work productivity reduction (WPR), aligning with the findings from the linear regression analysis and Pearson's correlation calculation. Among males, the strongest association is observed in overweight individuals, whereas in females, the relationship is most pronounced among obese individuals.

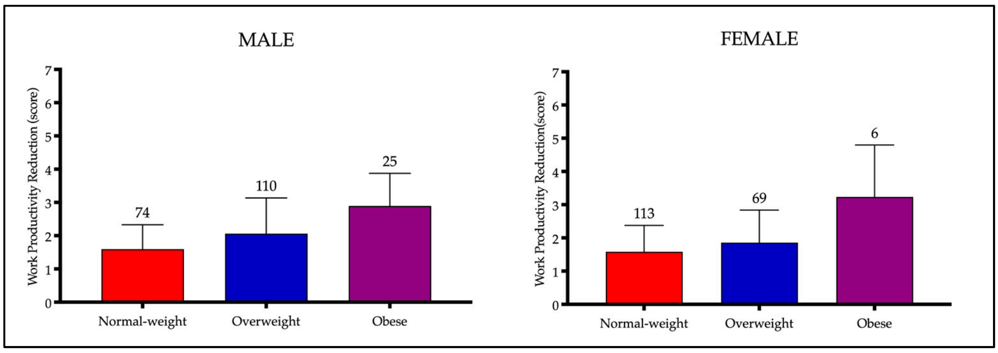
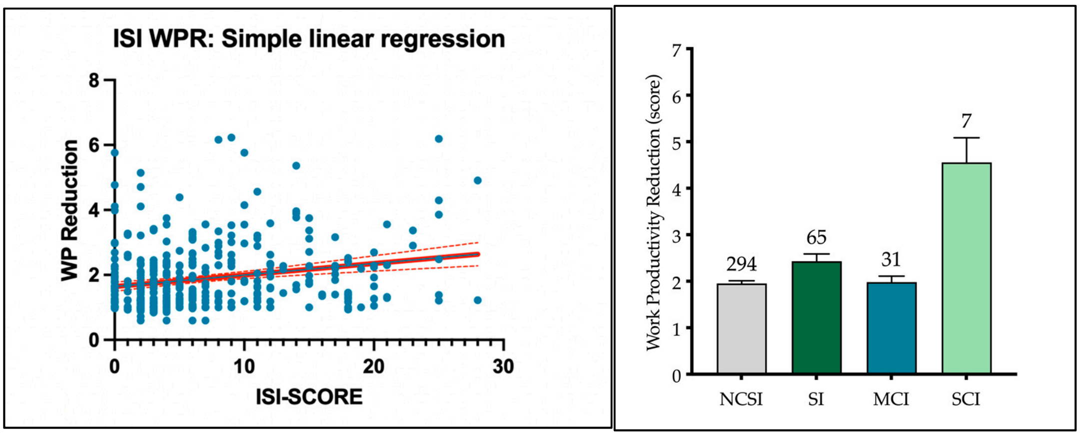


Figure 2. Relationship between BMI and WPR, stratifying subjects by gender (male, female) and grouped as normal weight, overweight, and obese.

3.2. Impact of Sleep Disorders on Work Productivity Reduction

A simple linear regression analysis was performed to examine the relationship between the ISI score (independent variable) and the reduction in labor productivity (dependent variable). The analysis yielded an R-squared value of 0.058, with an ISI-score coefficient of 0.0448 and a statistically significant p-value (<0.001). Additionally, the Pearson correlation coefficient between the ISI score and the reduction in labor productivity was calculated as 0.24, with a highly significant p-value (approximately 1.28×10^{-6}). These results indicate a moderate, statistically significant positive correlation between the two variables (Figure 3).



(**A**) (**B**)

Figure 3. (**A**) Linear regression graph and (**B**) bar graph explaining the relationship between ISI score and WPR.

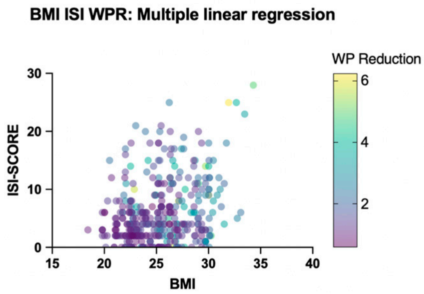
The figure illustrates a general trend indicating that higher ISI values are associated with greater reductions in work productivity, aligning with the findings of the linear regression analysis and Pearson's correlation coefficient calculations. Notably, among males, the association is most pronounced in overweight individuals, whereas among females, the strongest relationship is observed in obese individuals.

3.3. Impact of BMI and Sleep Disorders on Work Productivity Reduction

To analyze the combined effect of body mass index (BMI) and ISI score on work productivity reduction, we conducted a multiple linear regression analysis, setting both BMI and ISI score as independent variables (predictors) and work productivity reduction as the dependent variable.

This methodology allowed us to assess the impact of each independent variable on the dependent variable while controlling for the influence of the other predictors in the model. Additionally, we examined the coefficient of determination (R-squared) to evaluate the extent to which the model explains the variance in work productivity reduction.

The multiple linear regression analysis produced the following results: an R-squared value of 0.162, a BMI coefficient of 0.1147 (p-value < 0.001), and an ISI-score coefficient of 0.0256 (p-value < 0.005) (Figure 4).



	p-value	Pearson Coeff.	R-squared	Variable Coefficient
BMI on WPR	< 0.001	0.38	0.145	0.1288
ISI on WPR	< 0.001	0.24	0.058	0.0448
BMI+ISI on WPR	< 0.0001		0.162	0.1147 (for BMI) 0.0256 (for ISI)

Figure 4. BMI + ISI multiple linear regression graph on WPR and summary table.

These results suggest that both body mass index (BMI) and ISI score have a significant impact on work productivity reduction when considered together. Although BMI appears to have a greater influence on WPR than ISI score, based on the coefficients in the model, we recognize that the presented estimates are crude and not standardized (BMI is a continuous index calculated as weight divided by height squared (kg/m^2), with values generally above 10 and ranging up to 40 or more, while ISI is a discrete scale based on a score ranging from 0 to 28, dividing participants into categories such as mild, moderate, and severe insomnia). Because the independent variables are measured on different scales, direct comparisons should be interpreted with caution. We attempted to use standardized coefficients (z-scores); however, the sample was too small to allow this.

3.4. Comparing BMI and Sleep Disorder Groups in Terms of Work Productivity Reduction Using ANOVA

Considering the p-values of less than 0.001 for both the BMI groups and the ISI-score groups, the interaction between the BMI groups and the ISI-score groups was also significant (p-value = 0.014), indicating that the interaction between BMI and ISI-score groups has a statistically significant effect on work productivity reduction.

The results of the one-way repeated measures ANOVA revealed significant differences [F(11, 385) = 10.08; $p < 0.0001$] in work productivity reduction when comparing subjects with different BMI and ISI-score categories. Specifically, Tukey's post hoc test highlighted a significant work productivity reduction in subjects with SCI compared to those with NCSI, SI, and MCI (q = 5.431, $p < 0.0079$; q = 4.804, $p < 0.0358$; q = 5.271, $p < 0.0118$). Additionally, there was a pronounced work productivity reduction among obese subjects with SCI compared to overweight subjects with SCI (q = 4.822, $p < 0.0344$) and compared to obese subjects with MCI/SI/NCSI (Figure 5).

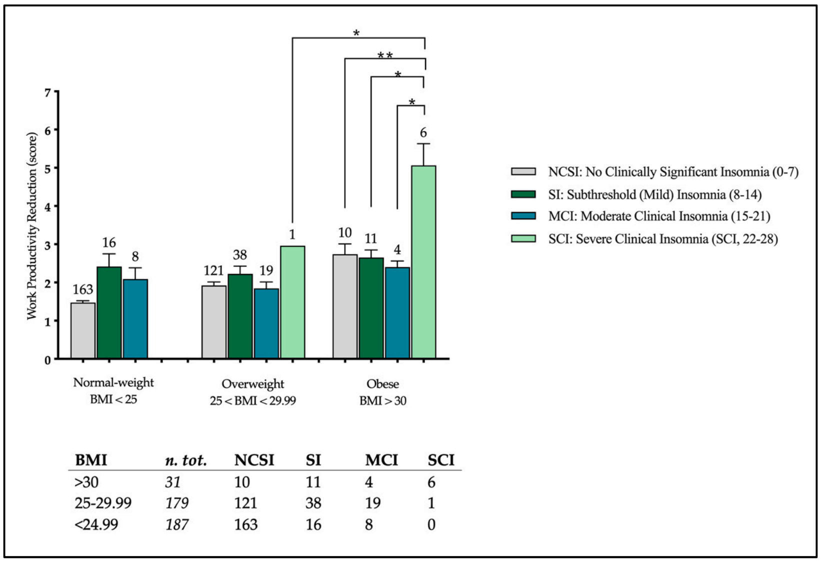


Figure 5. Differences in WPR in subjects of different weight categories and with different degrees of insomnia. Data are shown as mean ± SEM. * $p < 0.05$; ** $p < 0.01$.

Figure 5 presents a grouped bar graph illustrating the mean work productivity reduction across different BMI categories on the X axis, with each ISI-score group represented by distinct bar colors. Each bar signifies the average work productivity reduction for a specific BMI category, differentiated by the corresponding ISI-score group through color coding.

Statistical significance is indicated by asterisks: "*" for $p < 0.05$ (significant), "**" for $p < 0.01$ (very significant), and "***" for $p < 0.001$ (extremely significant).

Furthermore, an ANOVA comparing the two genders (male and female) was conducted, yielding a p-value of 0.0135 and an R-squared value of 0.153, indicating a statistically significant difference in work productivity reduction between genders (Figure 6).

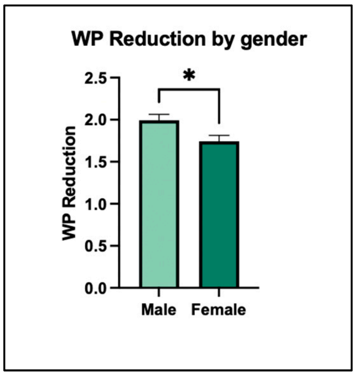


Figure 6. Differences in WPR by gender. Data are shown as SEM −0.2494 ± 0.1005; * $p < 0.05$.

4. Discussion

Obesity constitutes a significant health and economic burden in Italy. According to ISTAT data, approximately 10.37% of the Italian population is obese, and 32.53% is overweight [40]. These figures are particularly concerning in an era that emphasizes prevention, healthy eating lifestyles, and regular physical activity [41].

Obesity and sleep disorders are critical risk factors that play a significant role both in the development of complex syndromes and in adversely affecting individuals' daily lives [2].

As highlighted in the literature, the impact of body mass index (BMI) and insomnia on reduced work activity is multifaceted. Ćopić et al. (2020) investigated the effect of shift work on nutritional status and found that physical activity is strongly associated with lower BMI values. This indicates that lifestyle factors and regular physical activity can play a crucial role in managing BMI and mitigating its negative impact on work activity [42]. Conversely, Vitale et al. (2023) examined how shift work influences the onset of conditions such as anxiety, depression, and sleep disorders. Their study did not find a significant correlation of BMI and insomnia with the reduction in work activity in nurses performing shift work, suggesting that the relationship between BMI, insomnia, and work activity may be more complex and influenced by other factors such as the type of work and lifestyle [43].

In our study, focusing on workers and considering the primary disorders that may impair work activity, we sought to assess the relationship between reduced work productivity and two potential predictors: BMI and the insomnia severity index (ISI). Understanding these relationships is crucial, as they can inform interventions to improve work productivity, with potential benefits for both individual well-being and organizational performance.

Our sample included various parameters, encompassing demographic, health, and productivity measures. Descriptive statistics provided insights into study population characteristics such as age distribution, BMI and insomnia prevalence, and a higher prevalence of reduced productivity in males compared to females.

Regarding BMI, our data revealed a significant relationship between BMI and reduced work productivity. This finding indicates that overweight and obesity can have a direct impact on an individual's ability to work, possibly due to associated illnesses that may affect concentration, energy levels, and workplace attendance.

Research consistently shows that individuals with a higher BMI often face various health problems, such as cardiovascular disease, diabetes, and musculoskeletal issues [44]. These health conditions can directly impair an individual's ability to perform work tasks, particularly those requiring physical activity. Additionally, the presence of chronic diseases associated with obesity can lead to increased absenteeism due to medical appointments, treatments, and hospitalizations [45].

Beyond physical health, obesity is linked to negative mental health outcomes, including depression and anxiety [46]. These mental health conditions can further reduce work productivity by impairing concentration, motivation, and cognitive functions. Mental health problems can lead to presenteeism, where employees are physically present at work but are significantly less productive due to their condition.

Similarly, in our study, a reduction in work productivity was found in subjects with a high degree of insomnia, with a directly proportional correlation between the ISI score and work productivity reduction. Insomnia—characterized by difficulty falling asleep or staying asleep or experiencing non-restorative sleep—affects a significant portion of the working population. The ISI score, a clinical assessment tool, measures the nature, severity, and impact of insomnia. The relationship between insomnia, as measured by the ISI score, and work productivity is complex, involving direct and indirect pathways through physical and mental health, cognitive function, and broader socioeconomic implications.

Insomnia directly affects cognitive functions critical for work performance, including attention, concentration, decision making, and memory [47] and can be exacerbated by substance abuse such as alcoholism [48]. Individuals with a high ISI score often experience daytime fatigue, decreased alertness, and impaired executive functions, leading to errors, reduced efficiency, and the possibility of workplace accidents. The direct impact of insufficient sleep on cognitive and physical abilities can significantly hinder an individual's productivity and overall work performance. Furthermore, separate analyses by gender showed that the ISI score has a much stronger effect on females than BMI, which has a homogeneous impact on both sexes. This suggests that intervention strategies need to be tailored according to gender to effectively address sleep-related problems.

There is also a strong bidirectional relationship between insomnia and mental health disorders, particularly anxiety and depression [49]. These mental health problems can exacerbate the effects of insomnia on work productivity, leading to disrupted sleep cycles and deteriorating mental health. Individuals with high ISI scores and concomitant mental health problems are at increased risk of presenteeism, absenteeism, and job dissatisfaction.

Regarding the joint effect of BMI and ISI on the reduction in labor productivity, the analyses conducted in our study yielded statistically significant results. Both BMI and ISI scores demonstrated a synergistic impact on the reduction in labor productivity in our sample. The synergistic impact of BMI and insomnia on reduced work productivity is an emerging area of interest in occupational health research. This dual-factor approach recognizes that the interaction between physical and mental health factors, represented by BMI and insomnia, respectively, can exacerbate effects on an individual's work performance beyond what might be expected from each factor in isolation.

Future studies employing standardized coefficients will be needed to draw more definitive conclusions about the relative impact of BMI and ISI on productivity. Furthermore, given the relatively low R-squared value, it is plausible to infer that other variables not included in the model may also influence work productivity reduction.

When insomnia is simultaneously present, poor sleep quality and reduced sleep duration can exacerbate comorbidities, introducing additional cognitive and psychological burdens such as impaired memory, decreased concentration, and increased risk of depression and anxiety [50].

The economic implications of both the individual and combined impacts of BMI and insomnia on labor productivity are significant. Studies have shown that the costs associated with obesity and sleep disorders in the workplace amount to billions of dollars per year due to healthcare expenses, lost workdays, and decreased productivity [51]. Organizations face not only the direct costs of these health problems but also indirect costs associated with employee turnover, decreased morale, and the need for workplace adjustments or changes.

Among workplace health protection and prevention programs that can be implemented for the prevention and management of obesity, valuable examples can be drawn from interventions promoted in studies conducted by Malaeb et al. (2019), which included low-energy physical activity to improve nutritional status [52], or from interventions mentioned in the review by Brierley et al. (2019), aimed at identifying behaviors that can modulate cardiometabolic risk [53].

For the treatment of sleep disorders, non-pharmacological interventions are desirable due to the incompatibility of some work activities with pharmacological treatments. These interventions are among those established in the Workplace Health Promotion Programs of the Centers for Disease Control and Prevention. These initiatives target workplace health through a comprehensive and holistic strategy, incorporating components such as programs, policies, environmental support, benefits, and engagement with the broader community, all aimed at fulfilling the health and safety needs of every employee. Workplace health programs also incorporate strategies to improve sleep and reduce fatigue among employees. Such interventions could include offering workers access to tools that assess their sleep and provide targeted advice based on their results; adjusting room brightness to maximize alertness and minimize negative effects on subsequent sleep quality; and regulating temperature to avoid excessive warmth, which is not conducive to sleep [54,55].

As reported in recent studies, in order to fully achieve the concept of sustainable work, it is important that there are initiatives to promote physical and psychological job well-being in order to achieve suitable job satisfaction, with the establishment of trust between workers and employers reflected in improved productivity [56]

Finally, it should be considered that although both BMI and ISI scores play significant roles in determining work productivity reduction, other factors may also be critical. Further research and analysis, possibly with models that include additional variables, could provide a more comprehensive understanding of this phenomenon.

5. Conclusions

The findings of this study underscore the significant impact of obesity and insomnia, both independently and synergistically, on workplace productivity. These results highlight the need for integrated workplace interventions to concurrently address physical and mental health concerns. By incorporating nutritional counseling, physical activity programs, and cognitive behavioral therapies for insomnia, organizations can effectively reduce productivity losses and improve employee well-being.

This necessity extends to the combined role of BMI and insomnia, underscoring the need to implement comprehensive wellness programs and to support research on effective interventions. Only through such integrated efforts can the negative effects of these factors on productivity be mitigated, thereby enhancing both individual well-being and organizational performance.

Therefore, effective intervention strategies must address both weight management and sleep health to mitigate the individual and combined impacts of BMI and insomnia on work productivity. Workplace wellness programs that incorporate components such as nutritional counseling, initiatives to promote physical activity, cognitive behavioral therapy for insomnia (which is an effective tool for improving sleep parameters, particularly beneficial when tailored to the needs of individuals with high BMI), sleep hygiene education, and stress management can be especially helpful.

Future research should aim to further elucidate the mechanisms underlying the impact of BMI and insomnia on labor productivity. Longitudinal studies are needed to assess the long-term effects of adopted health interventions on productivity outcomes. Furthermore, exploring personalized intervention strategies that take into account individual differences in the response to treatment of obesity and insomnia could lead to even more effective management approaches.

6. Limitations of the Study

However, our study has several limitations. First, the sample consisted exclusively of workers from companies in Sicily who voluntarily participated in the survey, which limits the generalizability of the findings. Although the questionnaire was structured using validated scales, it relies on self-reported data (self-assessment), which may introduce bias related to participant preferences and the method used [55]. Employing numerical data, such as the number of health services provided, the ratio of employees, shift hours, and so forth, could potentially reduce this bias.

Author Contributions: Conceptualization: G.M. and E.C.; methodology: G.M. and F.P.; validation: G.M., F.P. and E.C.; formal analysis: G.M., F.P. and E.C.; investigation: G.M., E.C. and F.P.; resources: G.M. and E.C.; data curation: F.P., G.M. and E.C.; writing—original draft preparation: G.M. and E.C.; writing—review and editing: G.M. and E.C.; visualization: F.P.; supervision: E.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data are contained within the article.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Carnevali, E.; Godin, A.; Lucarelli, S.; Veronese Passarella, M. Productivity growth, Smith effects and Ricardo effects in Euro Area's manufacturing industries. *Metroeconomica* **2020**, *71*, 129–155. [CrossRef]
2. Zhang, W.; Tocher, P.; L'Heureux, J.; Sou, J.; Sun, H. Measuring, Analyzing, and Presenting Work Productivity Loss in Randomized Controlled Trials: A Scoping Review. *Value Health* **2023**, *26*, 123–137. [CrossRef] [PubMed]
3. Jiang, S.; Wang, Y.; Si, L.; Zang, X.; Gu, Y.-Y.; Jiang, Y.; Liu, G.G.; Wu, J. Incorporating productivity loss in health economic evaluations: A review of guidelines and practices worldwide for research agenda in China. *BMJ Glob. Health* **2022**, *7*, e009777. [CrossRef] [PubMed]
4. van den Heuvel, S.G.; Geuskens, G.A.; Hooftman, W.E.; Koppes, L.L.; van den Bossche, S.N. Productivity loss at work; health-related and work-related factors. *J. Occup. Rehabil.* **2010**, *20*, 331–339. [CrossRef]
5. Sanchez Bustillos, A.; Vargas, K.G., 3rd; Gomero-Cuadra, R. Work productivity among adults with varied Body Mass Index: Results from a Canadian population-based survey. *J. Epidemiol. Glob. Health* **2015**, *5*, 191–199. [CrossRef] [PubMed]
6. Cheng, P.; Drake, C. Occupational Sleep Medicine. *Sleep. Med. Clin.* **2016**, *11*, 65–79. [CrossRef] [PubMed]
7. Tejero, L.M.S.; Seva, R.R.; Fadrilan-Camacho, V.F.F. Factors Associated With Work-Life Balance and Productivity Before and During Work From Home. *J. Occup. Environ. Med.* **2021**, *63*, 1065–1072. [CrossRef]
8. Kolotkin, R.L.; Meter, K.; Williams, G.R. Quality of life and obesity. *Obes. Rev.* **2001**, *2*, 219–229. [CrossRef]
9. Chatterjee, A.; Gerdes, M.W.; Martinez, S.G. Identification of Risk Factors Associated with Obesity and Overweight-A Machine Learning Overview. *Sensors* **2020**, *20*, 2734. [CrossRef]
10. Swart, L.; Claassen, N.; Buys, T. Mapping the evidence on assessment of fitness to work at heights: A scoping review protocol. *BMJ Open* **2023**, *13*, e067847. [CrossRef] [PubMed]
11. Magnavita, N.; Capitanelli, I.; Garbarino, S.; Pira, E. Work-related stress as a cardiovascular risk factor in police officers: A systematic review of evidence. *Int. Arch. Occup. Environ. Health* **2018**, *91*, 377–389. [CrossRef] [PubMed]
12. Anderson, M.R.; Shashaty, M.G.S. Impact of Obesity in Critical Illness. *Chest* **2021**, *160*, 2135–2145. [CrossRef] [PubMed]
13. Ippoliti, F.; Corbosiero, P.; Canitano, N.; Massoni, F.; Ricciardi, M.R.; Ricci, L.; Archer, T.; Ricci, S. Work-related Stress, over-nutrition and cognitive disability. *Clin. Ter.* **2017**, *168*, e42–e47. [CrossRef]
14. Lee, H.; Ahn, R.; Kim, T.H.; Han, E. Impact of Obesity on Employment and Wages among Young Adults: Observational Study with Panel Data. *Int. J. Environ. Res. Public Health* **2019**, *16*, 139. [CrossRef] [PubMed]
15. OECD. *Health at a Glance 2023: OECD Indicators*; OECD Publishing: Paris, France, 2023. [CrossRef]
16. GBD 2017 Risk Factor Collaborators. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990–2017: A systematic analysis for the Global Burden of Disease St. *Lancet* **2018**, *392*, 1923–1994. [CrossRef] [PubMed]
17. Dai, H.; Alsalhe, T.A.; Chalghaf, N.; Riccò, M.; Bragazzi, N.L.; Wu, J. The global burden of disease attributable to high body mass index in 195 countries and territories, 1990–2017: An analysis of the Global Burden of Disease Study. *PLoS Med.* **2020**, *17*, e1003198. [CrossRef] [PubMed]
18. Chen, S.; Yang, L.; Yang, Y.; Shi, W.; Stults-Kolehmainen, M.; Yuan, Q.; Wang, C.; Ye, J. Sedentary behavior, physical activity, sleep duration and obesity risk: Mendelian randomization study. *PLoS ONE* **2024**, *19*, e0300074. [CrossRef] [PubMed]
19. Malta, G.; Plescia, F.; Zerbo, S.; Verso, M.G.; Matera, S.; Skerjanc, A.; Cannizzaro, E. Work and Environmental Factors on Job Burnout: A Cross-Sectional Study for Sustainable Work. *Sustainability* **2024**, *16*, 3228. [CrossRef]
20. Cirrincione, L.; Plescia, F.; Malta, G.; Campagna, M.; Lecca, L.I.; Skerjanc, A.; Carena, E.; Baylon, V.; Theodoridou, K.; Fruscione, S.; et al. Evaluation of Correlation between Sleep and Psychiatric Disorders in a Population of Night Shift Workers: A Pilot Study. *Int. J. Environ. Res. Public Health* **2023**, *20*, 3756. [CrossRef]
21. Lo Coco, D.; Cupidi, C.; Mattaliano, A.; Baiamonte, V.; Realmuto, S.; Cannizzaro, E. REM sleep behavior disorder in a patient with frontotemporal dementia. *Neurol. Sci.* **2012**, *33*, 371–373. [CrossRef] [PubMed]
22. Olszowka, M.; Held, C.; Hadziosmanovic, N.; Denchev, S.; Manolis, A.; Wallentin, L.; White, H.D.; Stewart, R.A.H.; Hagström, E.; Stability Investigators. Excessive daytime sleepiness, morning tiredness and major adverse cardiovascular events in patients with chronic coronary syndrome. *J. Int. Med.* **2021**, *290*, 392–403. [CrossRef]
23. Rajaratnam, S.M.; Arendt, J. Health in a 24-h society. *Lancet* **2001**, *358*, 999–1005. [CrossRef] [PubMed]
24. Okamoto, S. Hours of work and health in Japan. *Ann. Epidemiol.* **2019**, *33*, 64–71. [CrossRef] [PubMed]

25. Boivin, D.B.; Boudreau, P.; Kosmadopoulos, A. Disturbance of the Circadian System in Shift Work and Its Health Impact. *J. Biol. Rhythm.* **2022**, *37*, 3–28. [CrossRef]
26. Cannizzaro, E.; Cirrincione, L.; Mazzucco, W.; Scorciapino, A.; Catalano, C.; Ramaci, T.; Ledda, C.; Plescia, F. Night-Time Shift Work and Related Stress Responses: A study of security guards. *Int. J. Environ. Res. Public Health* **2020**, *17*, 562. [CrossRef]
27. Rapisarda, V.; Cannizzaro, E.; Barchitta, M.; Vitale, E.; Cinà, D.; Minciullo, F.; Matera, S.; Bracci, M.; Agodi, A.; Ledda, C. A Combined Multidisciplinary Intervention for Health Promotion in the Workplace: A Pilot Study. *J. Clin. Med.* **2021**, *10*, 1512. [CrossRef] [PubMed]
28. Lu, X.; Yu, H.; Shan, B. Relationship between Employee Mental Health and Job Performance: Mediation Role of Innovative Behavior and Work Engagement. *Int. J. Environ. Res. Public Health* **2022**, *19*, 6599. [CrossRef]
29. World Health Organization. *WHO Guidance on Research Methods for Health Emergency and Disaster Risk Management, Revised 2022*; World Health Organization: Geneva, Switzerland, 2022. Available online: https://iris.who.int/handle/10665/363502 (accessed on 23 July 2024).
30. Gallagher, D.; Heymsfield, S.B.; Heo, M.; Jebb, S.A.; Murgatroyd, P.R.; Sakamoto, Y. Healthy percentage body fat ranges: An approach for developing guidelines based on body mass index. *Am. J. Clin. Nutr.* **2000**, *72*, 694–701. [CrossRef] [PubMed]
31. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*, 5th ed.; American Psychiatric Association: Washington, DC, USA, 2013. [CrossRef]
32. Morin, C.M.; Belleville, G.; Bélanger, L.; Ivers, H. The Insomnia Severity Index: Psychometric indicators to detect insomnia cases and evaluate treatment response. *Sleep* **2011**, *34*, 601–608. [CrossRef]
33. Buysse, D.J.; Reynolds, C.F.; Monk, T.H.; Berman, S.R.; Kupfer, D.J. The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatry Res.* **1989**, *28*, 193–213. [CrossRef]
34. Fung, K.W.; Xu, J.; Bodenreider, O. The new International Classification of Diseases 11th edition: A comparative analysis with ICD-10 and ICD-10-CM. *J. Am. Med. Inform. Assoc.* **2020**, *27*, 738–746. [CrossRef]
35. Zhang, W.; Bansback, N.; Boonen, A.; Young, A.; Singh, A.; Anis, A.H. Validity of the work productivity and activity impairment questionnaire--general health version in patients with rheumatoid arthritis. *Arthritis Res. Ther.* **2010**, *12*, R177. [CrossRef] [PubMed]
36. Teich, N.; Grümmer, H.; Jörgensen, E.; Liceni, T.; Holtkamp-Endemann, F.; Fischer, T.; Hohenberger, S. Golimumab in real-world practice in patients with ulcerative colitis: Twelve-month results. *World J. Gastroenterol.* **2020**, *26*, 2852–2863. [CrossRef] [PubMed]
37. Bogduk, N. On understanding the validity of diagnostic tests. *Interv Pain Med.* **2022**, *1* (Suppl. S2), 100127. [CrossRef] [PubMed]
38. Spierings, E.L.H.; Ning, X.; Ramirez Campos, V.; Cohen, J.M.; Barash, S.; Buse, D.C. Improvements in quality of life and work productivity with up to 6 months of fremanezumab treatment in patients with episodic and chronic migraine and documented inadequate response to 2 to 4 classes of migraine-preventive medications in the phase 3b FOCUS study. *Headache* **2021**, *61*, 1376–1386. [CrossRef] [PubMed]
39. Muennig, P.; Lubetkin, E.; Jia, H.; Franks, P. Gender and the burden of disease attributable to obesity. *Am. J. Public Health* **2006**, *96*, 1662–1668. [CrossRef] [PubMed]
40. Masocco, M.; Minardi, V.; Contoli, B.; Minelli, G.; Manno, V.; Cobellis, L.; Greco, D. Sovrappeso e obesità nella popolazione adulta in Italia: Trend temporali, differenze socio-anagrafiche e regionali con focus sulla Regione Campania. *Boll. Epidemiol. Naz.* **2023**, *4*, 1–8. [CrossRef]
41. Afshin, A.; Forouzanfar, M.H.; Reitsma, M.B.; Sur, P.; Estep, K.; Lee, A.; Murray, C.J.L. Health effects of overweight and obesity in 195 countries over 25 years. *N. Engl. J. Med.* **2017**, *377*, 13–27. [PubMed]
42. Ćopić, N.; Kukić, F.; Tomić, I.; Parčina, I.; Dopsaj, M. The Impact of Shift Work on Nutritional Status of Police Officers. *NBP J. Crim. Law.* **2020**, *25*, 3–14. [CrossRef]
43. Vitale, E.; Lupo, R.; Artioli, G.; Mea, R.; Lezzi, P.; Conte, L.; De Nunzio, G. How shift work influences anxiety, depression, stress and insomnia conditions in Italian nurses: An exploratory study. *Acta Biomed.* **2023**, *94*, e2023102. [CrossRef]
44. Finkelstein, E.A.; DiBonaventura M d Burgess, S.M.; Hale, B.C. The costs of obesity in the workplace. *J. Occup. Environ. Med.* **2010**, *52*, 971–976. [CrossRef] [PubMed]
45. Gates, D.M.; Succop, P.; Brehm, B.J.; Gillespie, G.L.; Sommers, B.D. Obesity and presenteeism: The impact of body mass index on workplace productivity. *J. Occup. Environ. Med.* **2008**, *50*, 39–45. [CrossRef]
46. Luppino, F.S.; de Wit, L.M.; Bouvy, P.F.; Stijnen, T.; Cuijpers, P.; Penninx, B.W.; Zitman, F.G. Overweight, obesity, and depression: A systematic review and meta-analysis of longitudinal studies. *Arch. General. Psychiatry* **2010**, *67*, 220–229. [CrossRef] [PubMed]
47. Altena, E.; Baglioni, C.; Espie, C.A.; Ellis, J.; Gavriloff, D.; Holzinger, B.; Schlarb, A.; Frase, L.; Jernelöv, S.; Riemann, D. Dealing with sleep problems during home confinement due to the COVID-19 outbreak: Practical recommendations from a task force of the European CBT-I Academy. *J. Sleep. Res.* **2020**, *29*, e13052. [CrossRef] [PubMed]
48. Plescia, F.; Cirrincione, L.; Martorana, D.; Ledda, C.; Rapisarda, V.; Castelli, V.; Martines, F.; Vinnikov, D.; Cannizzaro, E. Alcohol Abuse and Insomnia Disorder: Focus on a Group of Night and Day Workers. *Int. J. Environ. Res. Public Health* **2021**, *18*, 13196. [CrossRef]

49. Baglioni, C.; Battagliese, G.; Feige, B.; Spiegelhalder, K.; Nissen, C.; Voderholzer, U.; Lombardo, C.; Riemann, D. Insomnia as a predictor of depression: A meta-analytic evaluation of longitudinal epidemiological studies. *J. Affect. Disord.* **2011**, *135*, 10–19. [CrossRef] [PubMed]
50. Bollu, P.C.; Kaur, H. Sleep Medicine: Insomnia and Sleep. *Mo. Med.* **2019**, *116*, 68–75. [PubMed]
51. Kessler, R.C.; Berglund, P.A.; Coulouvrat, C.; Hajak, G.; Roth, T.; Shahly, V.; Shillington, A.C.; Stephenson, J.J.; Walsh, J.K. Insomnia and the performance of US workers: Results from the America insomnia survey. *Sleep* **2011**, *34*, 1161–1171. [CrossRef] [PubMed]
52. Malaeb, S.; Perez-Leighton, C.E.; Noble, E.E.; Billington, C. A "NEAT" Approach to Obesity Prevention in the Modern Work Environment. *Workplace Health Saf.* **2019**, *67*, 102–110. [CrossRef]
53. Brierley, M.L.; Chater, A.M.; Smith, L.R.; Bailey, D.P. The Effectiveness of Sedentary Behaviour Reduction Workplace Interventions on Cardiometabolic Risk Markers: A Systematic Review. *Sports Med.* **2019**, *49*, 1739–1767. [CrossRef] [PubMed]
54. Ramar, K.; Malhotra, R.K.; Carden, K.A.; Martin, J.L.; Abbasi-Feinberg, F.; Aurora, R.N.; Kapur, V.K.; Olson, E.J.; Rosen, C.L.; Rowley, J.A.; et al. Sleep is essential to health: An American Academy of Sleep Medicine position statement. *J. Clin. Sleep. Med.* **2021**, *17*, 2115–2119. [CrossRef] [PubMed]
55. Yang, Y.; Obrenovic, B.; Kamotho, D.W.; Godinic, D.; Ostic, D. Enhancing Job Performance: The Critical Roles of Well-Being, Satisfaction, and Trust in Supervisor. *Behav. Sci.* **2024**, *14*, 688. [CrossRef] [PubMed]
56. Podsakoff, P.M.; Organ, D.W. Self-reports in organizational research: Problems and prospects. *J. Manag.* **1986**, *12*, 531–544. [CrossRef]