Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 10, 1079-1092
2025
Publisher: Learning Gate
DOI: 10.55214/2576-8484.v9i10.10601

Prevalence of occupational musculoskeletal disorders forced by telework during the covid-19 pandemic: A case study at the Universidad Nacional del Centro del Perú

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Abstract: The shift to widespread telework during the COVID-19 pandemic has raised concerns about its potential impact on musculoskeletal health. Factors such as suboptimal home office setups, prolonged working hours, physical conditions, and COVID-19 infection can contribute to the risk of developing musculoskeletal disorders (MSDs). Therefore, the aim of this research was to analyze the emergence of MSDs due to telework combined with COVID-19 among the administrative staff of UNCP. Data were obtained through personal interviews using the Nordic Musculoskeletal Questionnaire (NMQ), supplemented with information on hours and days of computer work. Two statistical models, binary logistic regression and conditional probability (Bayes' theorem), were applied to evaluate MSDs associated with COVID-19 and telework. The results indicated significant musculoskeletal discomfort in the shoulders, elbows, wrists, hips/legs, knees, and ankles/feet. Particularly notable was the occurrence of pain on both body hemispheres, including the shoulder (83), elbow (105), and wrist (84). While size, weight, and daily working hours appear to play important roles in understanding factors influencing MSDs during telework, the number of teleworking days per week did not significantly predict MSD prevalence. Most MSDs in different body regions showed weak or inconclusive relationships with the combination of COVID-19 and telework; however, notable exceptions were hip/leg and knee MSDs, which exhibited moderate and significant negative associations. Logistic regression and Bayes' theorem analyses, using a 0.51 threshold, revealed positive and negative relationships, respectively, between COVID-19 status and the probability of experiencing MSDs during teleworking.
Keywords: *Bayes' theorem, COVID-19, Logistic regression, Musculoskeletal disorders, Telework.*

1. Introduction

The COVID-19 pandemic has profoundly altered people's lives and work habits [1, 2] and has dramatically impacted employment worldwide [3, 4]. To contain the spread of the virus, many countries imposed extensive mobility restrictions [5-7], especially affecting workplaces, which led to job losses or reduced working hours [1, 4, 8-10]. Since the onset of the pandemic, workers have been instructed to work from home to limit the transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [1, 4, 10-12]. This shift in the work environment has introduced

History: Received: 17 July 2025; Revised: 28 August 2025; Accepted: 2 September 2025; Published: 17 October 2025
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significant changes in ergonomics and added new challenges for occupational health [13-17], particularly regarding the prevention and reduction of musculoskeletal pain [17-21].

According to the European Agency for Safety and Health at Work (EU-OSHA), work-related musculoskeletal disorders (MSDs) remain among the most common occupational health issues [4, 5, 22]. Physical risk factors for their development include repetitive movements and awkward postures [23-25]. To minimize risks in the workplace, employers must adhere to basic standards for safety and health in computer work [3, 4, 10, 11, 15, 22, 24, 26]. Consequently, many international organizations have recommended that institutions support their employees by allowing and assisting them in using office equipment at home [22, 26-28].

The COVID-19 pandemic has presented a global challenge to various aspects of our lives, both personal and professional [29-32]. WHO recommendations focus primarily on maintaining safety, hygiene, and social distancing as measures to curb the spread of COVID-19 [2-4, 29, 33]. In response, many countries instructed their populations to stay at home [6, 11, 16] and limit activities outside the home [1, 6, 11]. As a result of the abrupt shutdown, businesses, organizations, universities, schools, and public and government offices were forced to close [6, 8, 10, 17]. Many companies and offices transitioned to remote work [33, 34], encouraging employees to telecommute whenever possible [27, 31].

During the pandemic, people adapted to spending long hours using computers and laptops [10, 11, 16, 17, 22] for work, study, and home entertainment [1, 2, 33]. Many studies have confirmed the significant impact of the pandemic on the prevalence of musculoskeletal disorders [14, 18, 20, 21, 35-38] particularly affecting the neck, back, shoulders, and elbows [10, 11, 13, 15, 16, 22, 26].

Due to the COVID-19 pandemic, there was an urgent need for companies and their employees to start or expand remote work [3, 8, 27, 28, 33, 39]. Until March 2020, "working from home" was not a popular option for most Peruvian organizations, although it had begun to be implemented in 2013 [1, 3, 5, 9, 31, 39]. However, the onset of the COVID-19 pandemic made it the only viable option [10, 11, 13, 15, 16]. Working from home is not a new phenomenon; it first emerged in response to the oil crisis of the 1970s [4, 9, 10, 31]. Although terms such as telecommuting, remote work, working from home, mobile work, and telework are often used interchangeably, working from home remains the most commonly used term [1, 4, 10, 11], helping to prevent the spread of the COVID-19 virus [4, 39].

Recent advances in technology and communication have enabled an increasing number of people to work remotely, a trend known as telework [9, 14, 36]. Telecommuters report various positive outcomes [1, 8, 19] such as reduced stress from shorter commuting times, increased productivity due to fewer interruptions [3, 11, 18, 21], fewer sick days, and, depending on the company, greater flexibility in balancing personal and professional obligations [30, 40]. However, telework also presents challenges, including risks to physical and psychological health [11, 17, 24, 26].

Many office workers transitioned to working from home, and during this sudden shift [9, 17] many professionals lacked a suitable work environment [6, 8] leading to work-related musculoskeletal disorders (MSDs) with potential unintended consequences [4, 12, 27] such as reduced physical activity and poor posture, resulting in worsened health conditions [1, 11, 17, 24]. Prolonged workdays at home can restrict joint mobility [10, 11, 14] and contribute to postural discomfort due to the lack of ergonomically adequate workstations [10, 11, 22, 23].

Evidence suggests that an inadequate home environment can negatively affect job satisfaction, productivity levels [10, 11, 14, 22], work-related stress, and musculoskeletal health, especially during the COVID-19 pandemic [2, 5, 10, 39]. Recent studies have shown that working from home during the pandemic has had adverse impacts, such as decreased physical activity, increased screen time, reduced cognitive function, and an overall decline in quality of life [3, 10, 14-16, 18, 40]. As a result of the shift to telecommuting during the COVID-19 pandemic [22], many people may have experienced musculoskeletal problems or discomfort [10, 11, 13, 15, 16, 26]. Based on this situation, the present study aimed to analyze the likelihood of developing musculoskeletal disorders during the pandemic as a result of forced telecommuting among the teaching and administrative staff of the Universidad Nacional del Centro del Perú (UNCP).

2. Subjects and Methods

2.1. Data Information

Information on telecommuting, the Nordic Musculoskeletal Questionnaire, and data on individuals infected and not infected with COVID-19 were collected from the teaching and administrative staff of the Universidad Nacional del Centro del Perú (UNCP). According to UNCP's IT Department, the total number of people working or telecommuting during the pandemic was 1,100. For this research, the sample was selected using a probabilistic sampling method. The following mathematical model was applied to determine the number of individuals included in the study:

Limit of estimation error (B):$B_{\overline{X}} = t\,SE[\overline{X}] = t\sqrt{\hat{V}[\overline{X}]}$; where t is the Student's t-value for (n-1) degrees of freedom at the $(1-\sigma/2)$ significance level. The following approximations were reasonable for most cases: For σ=0.05, t≈2.0; For σ=0.10, t≈1.6; For σ=0.20, t≈1.3. The confidence interval was calculated as: $C.I. = \overline{X} \pm B_{\overline{X}}$. The sample size was determined using the following formula: $n = \frac{N*\sigma^2}{[N-1]*D+\sigma^2}$; where:$D = \frac{B^2}{t^2}$ and $\sigma^2 \approx S^2$. For a 95% confidence level, we used t = 2. Consequently, the total number of individuals surveyed among the teaching and administrative staff was 286.

2.2. Nordic Musculoskeletal Questionnaire

The Nordic Musculoskeletal Questionnaire (NMQ), internationally recognized and validated for detecting symptoms in the neck, back, shoulders, and limbs [17, 41-43], was used in this study. The questionnaire is divided into two parts: general and specific [41, 42]. The specific section was adapted to fit the circumstances and context of this research [11, 26, 44, 45]. It included variables such as COVID-19 status (yes/no) [26], working hours [22], weekly schedule [1], work posture [16], gender [22], weight [24], height [20], and age [9]. The questions addressed nine different body regions: neck, shoulders, elbows, wrists/hands, upper back, lower back, hips/thighs, knees, and ankles/feet [41, 42, 46].

2.3. Binary Logistic Regression and Conditional Probability

The binary regression model was employed to analyze how changes in predictor values are associated with changes in the probability of an event occurring [17, 40, 47, 48]. In logistic regression, the logistic transformation of probabilities (known as the logit) is used as the dependent variable [43, 47, 48]. In this study, the dependent variable was whether telecommuting and testing positive or negative for COVID-19 resulted in musculoskeletal disorders (MSDs) [40, 43]. By incorporating a regression equation for the independent variables, a logistic regression model was derived [24]:

$$\log[P] = \text{logit}[P] = \ln\left[\frac{P}{1-P}\right] = \text{logit}[P] = \beta_0 + \beta_1 * \beta_1 + \beta_2 * \beta_2 + \beta_3 * \beta_3 +$$

As in least squares regression, the relationship between logit[P] and X is assumed to be linear [23].

$$P = \frac{e^{[\beta_0+\beta_1*\beta_1+\beta_2*\beta_2+\beta_3*\beta_3+\cdots]}}{1+e^{[\beta_0+\beta_1*\beta_1+\beta_2*\beta_2+\beta_3*\beta_3+\cdots]}};\ P[WT \rightarrow MSDs] = P\left[\frac{\emptyset < 1 = No}{\emptyset > 1 = Si}\right]$$

In this equation, P can be calculated using the following formula [40] where P represents the probability that a case belongs to a specific category, e is the base of the natural logarithm (approximately 2.72), β_0 is the constant (intercept) of the equation, and β_1 is the coefficient (slope) of the predictor variable [17].

Additionally, Bayes' conditional probability was applied to determine the likelihood of a worker developing an MSD (in the neck, shoulder, upper back, lower back, elbow or forearm, or wrist or hand) as a result of the combined events of "COVID-19 + telework" [1, 10].

For two events A and B, the probability of event B occurring given that event A has occurred is denoted as P(B|A), and the probability of event A occurring given that event B has occurred is represented as P(A|B) [48, 49]. If event A occurs, then event B also occurs; if either A or B must occur and A must also occur, then P(B|A) = P(A|B) = 1, indicating deterministic reasoning [48, 50].

$$P\langle B_i|A\rangle = \frac{P\langle A|B_i\rangle P(B_i)}{\sum_{j=1}^{c} P\langle A|B_j\rangle P(B_j)} = \frac{P\langle A|B_i\rangle P(B_i)}{P(A)}$$

Among these, $P(B_i|A)$ is referred to as the posterior probability, representing the probability of each mutually exclusive condition B_i occurring after event A has occurred [49]. It can only be determined once the outcome of event A is known, which is why it is termed the posterior probability [50, 51].

3. Results

3.1. Occupational Patterns, Health Impacts, and Workload Analysis During COVID-19

Various physical and occupational characteristics of individuals were analyzed, focusing on musculoskeletal disorders (MSDs) during telework imposed by the COVID-19 pandemic. The data included hours worked per month, age, weight, height, daily work hours, workdays per month, gender, the presence of MSDs, and whether individuals had contracted COVID-19.

Table 1.
General Data Distribution: Hours, Age, Weight, Height, and Related Factors.

Data general		$\bar{X}$	Median	Max.	Mix.	SD	Normal
Hours x Months							
≤ 200	11	297.74	294	486	180	58.50	0.06
201 - 350	226						
≥ 351	49						
Age							
≤ 40	63	47.57	48	66	28	8.34	-0.05
41 - 55	168						
≥ 56	55						
Weight							
≤ 50	56	57.92	59	72	40	7.87	-0.14
51 - 65	189						
≥ 66	41						
Size							
≤ 1.60	77	1.63	1.62	1.75	1.53	0.06	0.18
1.61 - 1.70	153						
≥ 1.71	56						
Hours							
≤ 6	23	7.37	7	9	6	0.65	0.57
= 7	138						
≥ 8	125						
Days							
≤ 35	92	40.12	40	56	30	5.26	0.02
36 - 45	143						
≥ 46	51						
Gender		0.34	0	1	0	0.47	0.72
MSD		1.11	1.11	2	0.44	0.28	0.00
COVID-19		0.37	0	1	0	0.48	0.76

Note: It was observed that participants worked an average of nearly 300 hours per month, with low variation. The average age was 47.57 years, and the age range was between 28 and 66 years. Weight and height showed moderate consistency among individuals, while the average daily work hours were approximately 7.37. Musculoskeletal disorders (MSDs) were prevalent; 34% of the participants were male, and 37% had contracted COVID-19.

The analysis showed that participants worked an average of 297.74 hours per month, with a slightly skewed distribution. The median age was 48 years (range: 28–66) with a standard deviation (SD) of

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 10: 1079-1092, 2025
DOI: 10.55214/2576-8484.v9i10.10601

8.34. The average weight was 57.92 kg (SD = 7.87), with a slight negative skew. Height averaged 1.63 meters, showing a positive skew. Participants worked an average of 7.37 hours per day, with a maximum of 9 hours and a positive skew. The average number of workdays per month was 40.12, with a slight positive skew. Gender distribution indicated that 34% were male. Musculoskeletal disorders (MSDs) were common, with a mean of 1.11, while 37% had contracted COVID-19. Both MSDs and COVID-19 exhibited high positive skewness.

3.2. General Analysis of Musculoskeletal Disorders

The study on telecommuters from the Universidad Nacional del Centro del Perú (UNCP) during the COVID-19 pandemic revealed significant musculoskeletal problems. Participants reported pain in various parts of the body: neck (149), shoulders (87), elbows (74), wrists (83), upper back (152), lower back (143), hips/legs (177), knees (150), and ankles/feet (169).

The shoulders, elbows, wrists, hips/legs, knees, and ankles/feet also showed a considerable number of cases of musculoskeletal discomfort. Particularly concerning was the onset of pain on both sides of the body (Yes×2), especially in the shoulders (83), elbows (105), and wrists (84).

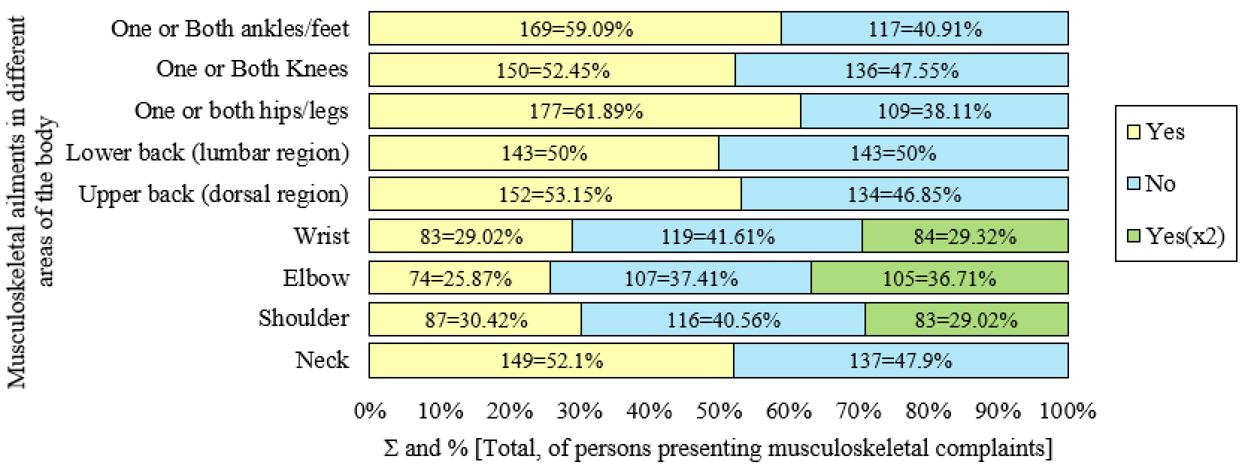

Figure 1.
Most repetitive musculoskeletal ailments among UNCP administrative teaching staff.
Note: The study on the prevalence of musculoskeletal disorders among workers at the "Universidad Nacional del Centro del Perú" who engaged in telework during the COVID-19 pandemic yielded revealing results. Participants reported experiencing musculoskeletal pain (Yes) or no pain (No) in various parts of the body.

These results highlight the physical toll of telecommuting and underscore the urgent need for ergonomic adjustments, workplace interventions, and health support measures to reduce musculoskeletal issues and improve the well-being of remote university staff. Addressing these concerns is essential for fostering a healthier and more sustainable telecommuting environment, especially amid the ongoing challenges posed by the COVID-19 pandemic.

3.3. Probability of Musculoskeletal Disorder as a Function of Their Physical Conditions and Time Distinction

Different probabilities of MSD were observed across various weight values, highlighting the multifactorial nature of factors contributing to musculoskeletal disorders during teleworking. The logistic regression model ($y = -0.0009x + 0.4221$) showed a slight negative correlation ($r = -0.032$) between the probability of MSD (P[MSD]) and weight (X = Weight (kg)). However, the t-test value ($t = -0.548$) did not reach significance (±1.960 at $p = 0.05$, two-tailed), suggesting that weight was not a statistically significant predictor of MSD. The low R^2 value (0.0011) indicated that only a minimal proportion of the variance in MSD was explained by weight.

ISSN: 2576-8484
Vol. 9, No. 10: 1079-1092, 2025
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When analyzing the dataset by height, different MSD probabilities were also observed, indicating that factors other than height may contribute to telework-related MSD among university workers. The logistic regression model (y = 0.3849x - 0.2609) revealed a positive correlation (r = 0.165) between the probability of MSD (P[MSD]) and height (X = Height (m)). The t-test value (t = 2.826) was statistically significant (greater than ±1.960 at p = 0.05, two-tailed), suggesting that height is a potential predictor of MSD. However, the low R^2 value (0.0273) indicated that height explained only a small proportion of the variance in MSD.

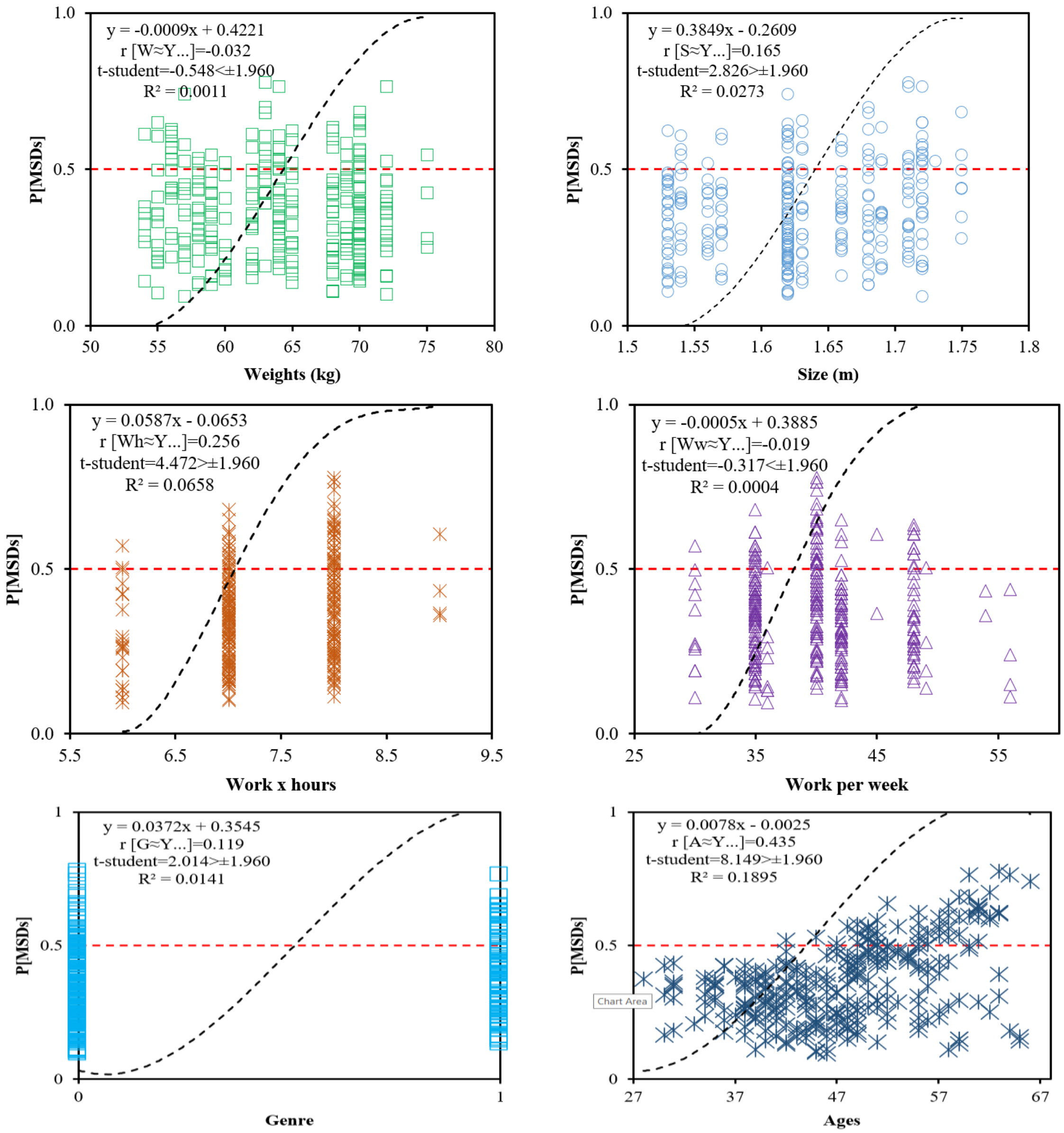

Figure 2.
Probability of presenting MSDs by physical anatomical characteristics and temporary work.
Note: The analysis of musculoskeletal disorders (MSDs) in relation to various factors during telework revealed that age had a moderate positive association with the probability of MSDs, with a higher explanatory power compared to gender, weight, and height. Although working hours showed a moderate positive relationship with MSDs, the overall explanatory power remained low. Gender, weight, and days per week demonstrated minimal or statistically non-significant associations with MSDs, suggesting that other factors may contribute more significantly to the prevalence of MSDs during telework.

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ISSN: 2576-8484
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The logistic regression model (y = 0.0587x - 0.0653) revealed a positive correlation between the probability of MSD (P[MSD]) and working hours (X = working hours). The correlation coefficient (r = 0.256) indicated a moderate positive relationship. The t-test result (t = 4.472) was statistically significant (greater than ±1.960 at p = 0.05, two-tailed), suggesting that this relationship was unlikely due to chance. The R^2 value (0.0658) showed that working hours explained approximately 6.58% of the variance in MSD, indicating low explanatory power.

The overall data showed variable probabilities of MSD across different working hours. The logistic regression model (y = -0.0005x + 0.3885) revealed a very weak negative correlation (r = -0.019) between the probability of MSD (P[MSD]) and days worked per week (X = days per week). However, the t-test value (t = -0.317) was not statistically significant (less than ±1.960 at p = 0.05, two-tailed), suggesting that the relationship between days per week and MSD was inconclusive. The low R^2 value (0.0004) indicated that days worked per week explained only a minimal amount of variance in MSD.

The logistic regression model for the probability of presenting an MSD based on gender was given by the equation y = 0.0372x + 0.3545. The correlation coefficient (r = 0.119) indicated a weak positive association between gender and the probability of MSD. The t-value (t = 2.014) exceeded the critical threshold of ±1.960, suggesting statistical significance. However, the R^2 value (0.0141) showed that gender explained only 1.41% of the variance in the probability of presenting an MSD, reflecting the model's low explanatory power.

In contrast, the logistic regression model for the probability of presenting an MSD based on age was represented by the equation y = 0.0078x − 0.0025. The correlation coefficient (r = 0.435) indicated a moderate positive association between age and the probability of MSD. The t-value (t = 8.149) exceeded the critical threshold of ±1.960, confirming statistical significance. The R^2 value (0.1895) suggested that age explained approximately 18.95% of the variance in the probability of presenting an MSD, indicating a higher explanatory power compared to the gender-based model.

3.4. Prevalence of Musculoskeletal Disorders due to Telework and COVID-19

With regard to Neck MSD versus COVID-19 + Telework, the regression equation suggested a weak positive relationship; however, the very low R^2 (0.0003) indicated limited explanatory power. Furthermore, the minimal positive correlation (r = 0.016) and the non-significant t-test value (0.274) implied that this relationship might be due to chance.

In contrast, the analysis of Shoulder MSD versus COVID-19 + Telework indicated a weak negative relationship, with a low R^2 (0.0004), and the non-significant t-test value (-0.316) provided inconclusive evidence regarding the association.

Similarly, for Elbow MSD versus COVID-19 + Telework, the model showed a weak positive relationship; however, the low explanatory power (R^2 = 0.0002) and the non-significant t-test value (0.217) suggested that the relationship was statistically uncertain.

Moreover, in the case of Wrist MSD versus COVID-19 + Telework, the results demonstrated a weak negative relationship, characterized by low explanatory power (R^2 = 0.0006) and a non-significant t-test value (-0.398), thereby suggesting that the relationship was unreliable.

Likewise, the findings for Dorsal Region MSD versus COVID-19 + Telework indicated a weak negative relationship, with low explanatory power (R^2 = 0.0005) and inconclusive evidence, as reflected in the non-significant t-test value (-0.382).

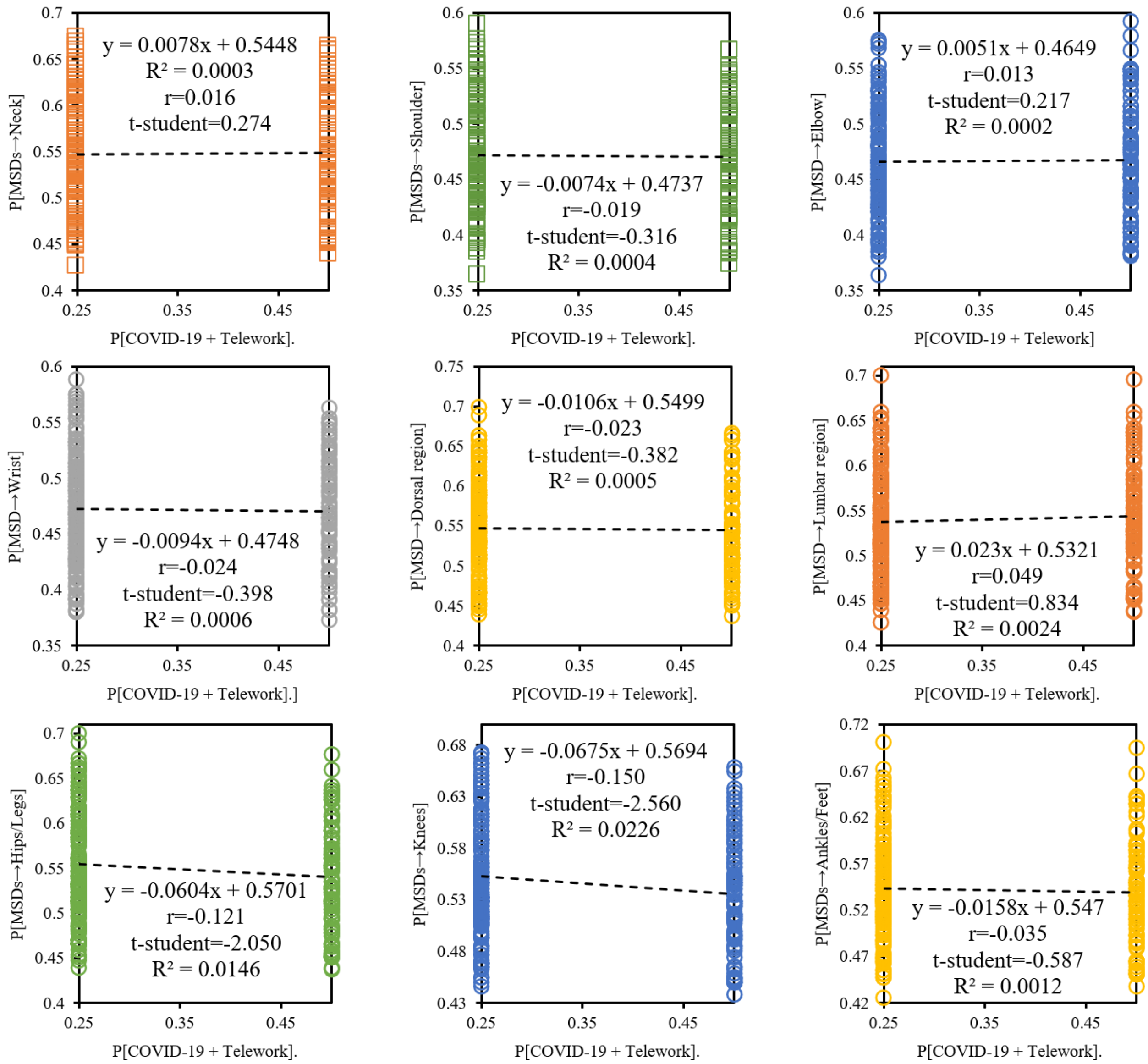

Figure 3.
Probability, conceiving MSDs (different body regions) by the effect of COVID-19 + Teleworking.
Note: Most of the MSDs investigated showed weak or inconclusive relationships with the combination of COVID-19 and telework. However, notable exceptions included MSDs of the hips/legs and knees, which exhibited moderate and significant negative associations with the combined effects of COVID-19 and telework. These results suggest that certain musculoskeletal issues may be more strongly influenced by the interaction between COVID-19 and teleworking, highlighting the need for further research and potential interventions to mitigate the associated risks.

On the other hand, the results for Lower Back MSD versus COVID-19 + Telework revealed a weak positive relationship, though with slightly higher explanatory power ($R^2 = 0.0024$). In addition, the t-test value (0.834) confirmed a weak but statistically significant positive association, indicating that lower back disorders were somewhat more likely under the combined conditions of telework and COVID-19.

DOI: 10.55214/2576-8484.v9i10.10601

Meanwhile, the analysis of Hips/Legs MSD versus COVID-19 + Telework demonstrated a moderate negative relationship, supported by moderate explanatory power ($R^2 = 0.0146$) and a significant negative association, as evidenced by the t-test value (-2.050).

Similarly, Knees MSD versus COVID-19 + Telework showed a moderate negative relationship, with moderate explanatory power ($R^2 = 0.0226$) and a significant negative association, confirmed by the t-test value (-2.560).

Finally, for Fingers/Feet MSD versus COVID-19 + Telework, the analysis demonstrated a weak negative relationship, accompanied by low explanatory power ($R^2 = 0.0012$) and uncertainty due to the non-significant t-test value (-0.587), indicating that the relationship lacked statistical reliability.

3.5. Affirmative Probability of Musculoskeletal Disorders Due to the Effect of Telework + COVID-19

In this analysis, the logistic regression model was applied to predict the probability of experiencing musculoskeletal disorders (P[MSD]) based on individuals' COVID-19 status. Specifically, a threshold value of 0.51 was established to determine the likelihood of MSD; thus, probabilities above this threshold indicated a higher chance of developing MSD as a result of COVID-19 infection combined with telework.

Regarding the dataset, it included two key variables: COVID-19 status (coded as 0 = no and 1 = yes) and the corresponding predicted probabilities of MSD (P[MSD]). When the COVID-19 status was 0, the predicted probabilities ranged from 0.0955 to 0.7391, with most values falling below the threshold of 0.51. Conversely, when the COVID-19 status was 1, the predicted probabilities ranged from 0.1399 to 0.7672, with some values exceeding the threshold, thereby suggesting a higher likelihood of MSD among those who had contracted COVID-19.

Furthermore, the second dataset utilized a binary logistic regression model, represented as:

$$P(\text{MSDs}) = \frac{e^{(\beta_0 + \text{COVID}-19^{\text{yes}}_{\text{no}} * \beta_1 + \text{Telework} * \beta_2 + \cdots)}}{1 + e^{(\beta_0 + \text{COVID}-19^{\text{yes}}_{\text{no}} * \beta_1 + \text{Telework} * \beta_2 + \cdots)}}$$

The logistic regression model indicated a positive relationship between COVID-19 and the probability of experiencing MSD, as evidenced by the positive slope coefficient (0.0925). Additionally, the moderate correlation coefficient (r) further supported a significant positive association between the two variables.

Overall, the threshold of 0.51 for predicting MSD highlighted that values exceeding this limit were indicative of a higher probability of developing MSD due to the combined effects of COVID-19 and telework. Consequently, this logistic regression model provided valuable insight into how COVID-19 infection and remote work conditions jointly influenced the prevalence of work-related MSD among staff members at the Universidad Nacional del Centro del Perú (UNCP).

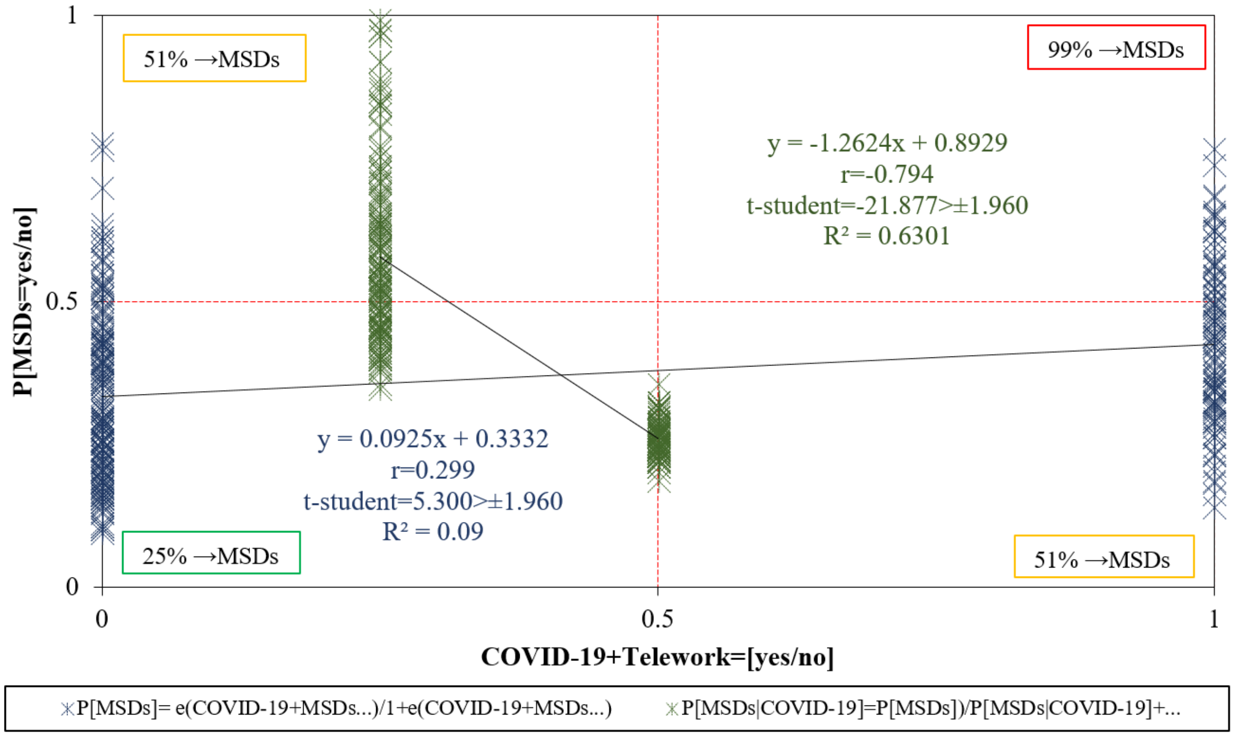

Figure 4.
Probability, conceiving MSDs (different body regions) by the effect of COVID-19 + Teleworking.
Note: When comparing the two sets of results, it was essential to consider the context and purpose of the analysis. The first model employed Bayes' theorem (logistic regression equation: y = -1.2624x + 0.8929, with ρ = -0.794, a t-test value of -21.877 greater than ±1.960 and an R^2 value of 0.6301), while the second used binary logistic regression (logistic regression equation: y = 0.0925x + 0.3332, with ρ = 0.299, a t-test value of 5.300 greater than ±1.960 and an R^2 value of 0.09). The higher t-test and R^2 values in the first model suggested a potentially better fit compared to the second.

In this analysis, the data incorporated two main variables: COVID-19 status (coded as 0.25 or 0.5) and the corresponding predicted probabilities of musculoskeletal disorders (P[MSDs|COVID-19]). The predicted probabilities ranged from 0.2199 to 0.9735, illustrating a wide distribution of MSD likelihood among participants.

When the COVID-19 status was 0.25, most probability values exceeded the threshold of 0.51, thereby suggesting a high likelihood of MSD under these conditions. In contrast, when the COVID-19 status increased to 0.5, the model predicted lower probabilities of MSD, with most values falling below the 0.51 threshold. This indicates an inverse relationship between COVID-19 status and the probability of developing MSD.

Moreover, a second dataset was analyzed using Bayes' theorem, where the logistic regression model was expressed as:

$$P(\text{ MSDs } | \text{ COVID } 19\text{ }) = \frac{P(\text{MSDs})}{\Sigma P(\text{MSDs } | \text{ COVID } 19) + \cdots}$$

In this model, the negative slope coefficient suggested that, overall, an increase in COVID-19 status was associated with a decrease in the probability of MSD occurrence. Furthermore, the high R^2 value indicated that the model effectively captured the variation in MSD probability based on COVID-19 status, thereby supporting the model's predictive validity.

Consistently, the threshold of 0.51 for predicting MSD aligned with the application of Bayes' theorem in the model, reinforcing its interpretative framework. Overall, the Bayesian-logistic model provided valuable insights into the relationship between COVID-19 and the likelihood of work-related

MSD. Specifically, the negative correlation implied that, within the context of teleworking during the COVID-19 pandemic, individuals with higher COVID-19 status exhibited a lower probability of developing MSDs. Finally, the established 0.51 threshold proved useful for identifying workers at greater risk of MSD in this particular population.

4. Discussion

4.1. Alterations in the Probability of Musculoskeletal Disorders Based on Physical Conditions and Time Distinction

This contrasts with the findings of Kulshrestha et al. [15], who did not explicitly focus on weight but observed discomfort in various regions, such as the neck (70%) and lower back (60%), among computer users during the COVID-19 lockdown. This finding is consistent with Gosain et al. [11] exploration of MSD prevalence among computer users during the COVID-19 pandemic, where different body regions were affected, and women were more prone to musculoskeletal pain than men. Gosain et al. [11] also explored MSD prevalence among computer users working from home and observed an increase in MSDs during the disconnection phase, especially among women. Kulshrestha et al. [15] did not specifically investigate days per week but observed discomfort in various regions, suggesting the multifaceted nature of the factors contributing to MSDs. Pirposhteh et al. [13] focused on factory workers in Iran and found significant correlations between perceived stress and musculoskeletal problems, highlighting the importance of psychological factors. Rodríguez-Nogueira et al. [26] analyzed the impact of confinement on musculoskeletal health and observed changes in lifestyle and musculoskeletal pain among university workers in Spain during the COVID-19 pandemic.

4.2. Discussions on the Prevalence of Musculoskeletal Disorders Due to the Effect of Telework and COVID-19

This contrasts with the findings of Gosain et al. [11], where neck pain was prevalent among computer users working from home during the COVID-19 pandemic. In Gosain et al. [11], shoulder pain was among the most affected regions for computer users during the pandemic, which aligns with the observed weak negative relationship. Gosain et al. [11] also observed elbow discomfort, though with a lower prevalence compared to other regions. They further reported discomfort in the wrist/hand among computer users, consistent with the weak negative relationship. This finding is similar to that of Rodríguez-Nogueira et al. [26], who observed changes in lifestyle and musculoskeletal pain among university workers during the COVID-19 pandemic. It also aligns with Kulshrestha et al. [15], who found discomfort in the lower back among computer users during the COVID-19 lockdown. It is likewise consistent with Kulshrestha et al. [15] and Gosain et al. [11], who reported musculoskeletal problems in the lower extremities during the COVID-19 pandemic. Similarly, Kulshrestha et al. [15] found that knee problems were prevalent among computer users during the COVID-19 lockdown. Additionally, it aligns with Kulshrestha et al. [15], who observed discomfort in the upper extremities among computer users during the COVID-19 lockdown. Overall, the results were consistent with those of other studies, such as those by Gosain et al. [11] and Kulshrestha et al. [15], which highlighted the prevalence of musculoskeletal disorders, especially in the neck, shoulders, and lower back regions, during the COVID-19 pandemic and the rise in telework.

4.3. Discussions on the Affirmative Probability of Musculoskeletal Disorders Due to the Effect of Telework + COVID-19

The studies collectively emphasized the impact of telework during the COVID-19 pandemic on musculoskeletal health, particularly in areas such as the neck, lower back, and shoulders. Psychological factors, lifestyle changes, and gender differences were recurring themes across the studies, reflecting the multifaceted nature of musculoskeletal problems during teleworking. The logistic regression models and Bayes' theorem provided valuable insights into the relationship between COVID-19, telework, and the probability of MSDs. Moreover, the established threshold of 0.51 served as a practical reference for identifying individuals at higher risk of MSDs in the studied population.

Gosain et al. [11] found that during the COVID-19 pandemic, computer users working from home experienced musculoskeletal pain, with neck, lower back, and shoulder pain being the most prevalent. This was consistent with the positive relationship observed in the logistic regression model. Similarly, Kulshrestha et al. [15] reported discomfort in the neck, lower back, upper back, and shoulders among computer users during the COVID-19 lockdown, supporting the conclusions of the logistic regression analysis. In addition, Cristancho et al. [16] determined that telework during the pandemic was associated with musculoskeletal disorders in teachers, particularly in the neck region, further reinforcing the positive relationship identified in the logistic regression model.

5. Conclusions

The analysis of teleworkers at the Universidad Nacional del Centro del Perú during the COVID-19 pandemic revealed significant musculoskeletal problems, with notable pain reported in various parts of the body. The most frequent discomfort was observed in the upper back, lower back, hips/legs, and ankles/feet.

Moreover, various physical conditions and work-related factors influenced the probability of musculoskeletal disorders (MSDs) among teleworkers. Height and working hours showed significant correlations with MSD, whereas weight, days per week, and gender did not. In contrast, age was identified as a notable predictor, explaining a substantial proportion of the variance in MSD, unlike gender, which demonstrated minimal explanatory power.

Additionally, the relationship between musculoskeletal disorders (MSDs) and telework, combined with COVID-19, varied across body regions. While MSDs in the lower back, hips/legs, and knees showed moderate negative relationships with moderate explanatory power, other regions, such as the neck, shoulders, and wrists, displayed weak and non-significant associations.

Finally, there was generally a positive relationship between COVID-19 status and the probability of experiencing musculoskeletal disorders (MSDs) due to telework, with a threshold of 0.51 indicating a higher probability of MSD occurrence. The logistic regression model determined a positive relationship between COVID-19 status and the likelihood of experiencing MSD during telework, whereas the Bayes' theorem model indicated a negative relationship between COVID-19 status and the probability of having MSD as a result of teleworking.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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