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Article

Evaluation of Allergic Reactions and Pulmonary Function in Individuals Working in Small Container-Like Spaces

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Abstract

Objective: The aim of this study was to objectively evaluate the presence of allergic reactions and pulmonary function in individuals working in small container-like spaces in Malatya following the February 6, 2023, Kahramanmaraş-centered earthquakes, and to examine their associations with physical activity, sleep quality, grip strength, and quality of life. **Methods:** This cross-sectional and descriptive study included 90 volunteers (aged 25–55 years) who had been working in container-like small spaces for at least two years. Sociodemographic characteristics, smoking status, and history of allergic reactions were collected using structured questionnaires. Pulmonary function was assessed using portable spirometry (FEV₁, FVC, FEV₁/FVC). Physical activity level was evaluated with the International Physical Activity Questionnaire–Short Form (IPAQ-SF), sleep quality with the Pittsburgh Sleep Quality Index (PSQI), and quality of life with the Short Form-36 (SF-36). Grip strength was measured using a digital dynamometer, and the highest value was used for analysis. **Results:** Of the participants, 92.2% were male, and the mean age was 39.0±9.5 years. The prevalence of self-reported allergic reactions was 5.6%. While FEV₁% (68.9±12.4) and FVC% (64.1±11.3) values were relatively low, the FEV₁/FVC ratio was preserved (0.86±0.06). As the mMRC dyspnea grade increased, significant decreases were observed in FEV₁% and FVC% values (p<0.001). Pulmonary function parameters showed significant associations with fatigue and the physical functioning and physical role subscales of the SF-36. **Conclusion:** Individuals working in small container-like spaces demonstrated a tendency toward reduced ventilatory capacity without overt airway obstruction, along with dyspnea-related pulmonary function impairment. These findings highlight the importance of early screening strategies (spirometry and dyspnea scales) and environmental interventions aimed at improving ventilation, ergonomics, and physical activity in such work environments.

Keywords: spirometry; respiratory function tests; indoor air pollution; quality of life

1. Introduction

Natural disasters are a significant public health problem that is not limited to trauma and mortality in the acute phase; they can also have lasting effects on physical health, mental health, and functionality in the medium to long term. Following the earthquakes centered in Kahramanmaraş on

February 6, 2023, housing and working conditions changed significantly in Malatya, as in many other provinces of Turkey; container cities became not only temporary housing areas but also working environments for a large number of individuals. While it is expected that this new working arrangement will have an impact on health outcomes, especially through long-term exposure to "small and enclosed spaces similar to containers," evidence in this area is limited.

It has been shown that the quality of life of individuals was significantly affected by social isolation and decreased levels of physical activity during the COVID-19 pandemic [1]. These findings suggest that a similar risk profile may emerge in individuals working in cramped spaces similar to containers after the earthquake.

There is evidence that recreational physical activities performed in open spaces increase life satisfaction and quality of life [2]. In contrast, it is thought that working in confined and enclosed spaces may limit this positive effect.

Stress disorder and rumination are frequently observed in individuals in the post-disaster period, and it has been reported that this can be reduced with increased physical activity and exercise approaches [3]. In this context, it can be said that the level of physical activity in individuals working in containers is important not only for physical well-being but also for psychological well-being.

Health-Related Characteristics of Container and Confined Space Working Environments

Small spaces such as containers can contain multiple risk factors that can impair indoor air quality, such as limited volume, inadequate air exchange, heat-humidity imbalance, chemical compounds that can be released from building/coating materials, and biological pollutants (e.g., mold spores). Indoor humidity and air quality have been found to be associated with eye/upper respiratory tract irritation, perceived "dry air", sleep quality, and some respiratory symptoms [4]. Furthermore, there are extensive reviews reporting that lower ventilation rates may be associated with adverse health outcomes such as increased inflammation, respiratory infections, and asthma symptoms [5]. A classic review evaluating the relationship between ventilation rates and CO₂ levels and health and performance outcomes in commercial/institutional buildings similarly emphasizes that inadequate ventilation conditions may be associated with complaints [6].

Non-specific symptom clusters such as headaches, fatigue, eye/throat irritation, and respiratory complaints seen in enclosed work environments are defined in the literature within the framework of "Sick Building Syndrome" [7]. The temporary/semi-temporary structural characteristics of containers, intensive use, heating-cooling practices, and limited ventilation can create a risky work environment in terms of these symptom clusters.

Allergic Reactions and Indoor Exposures

The relationship between indoor allergens (house dust mites, mold spores, some insect antigens, particulate matter, and irritant chemicals) and sensitization/symptom development has long been known. In particular, the contribution of indoor allergens to asthma burden and their role in the clinical course of allergic diseases has been strongly emphasized in the respiratory medicine literature [8]. In addition, systematic analyses showing that a significant proportion of adult-onset asthma may be associated with occupational exposures reveal that workplace history is critically important in clinical evaluation [9]. Working in containers after the earthquake can increase indoor exposures, triggering allergic rhinitis/dermatitis-like symptoms and asthma-like complaints; therefore, systematic questioning and classification of allergic reactions is necessary.

Respiratory Functions: The Need for Objective Assessment

Respiratory function tests are fundamental tools for objectively assessing the effect of indoor exposures on the respiratory system. FEV₁, FVC, and the FEV₁/FVC ratio are commonly used parameters in the assessment of obstructive patterns. GOLD reports and GOLD's spirometry guidelines highlight the clinical significance of the FEV₁/FVC ratio in assessing airflow obstruction[10,11]. In this context, spirometric measurements provide a valuable scientific basis for detecting subclinical or clinical exposures related to possible irritant/allergen exposures in individuals working in enclosed spaces such as containers.

Reduced Physical Activity, Musculoskeletal and Functional Indicators

Working in confined spaces can increase musculoskeletal problems due to limited range of motion, non-ergonomic postures, and repetitive/strength-requiring workloads. Strong epidemiological evidence highlights the role of ergonomic risks such as repetitive movements, strenuous exertion, inappropriate posture, and vibration in work-related musculoskeletal disorders[12]. Furthermore, it has been shown that social isolation and reduced physical activity negatively impacted quality of life during the COVID-19 period; these findings suggest a similar risk profile in restricted working conditions after the earthquake [1]. Validity and reliability studies of the IPAQ (International Physical Activity Questionnaire), one of the internationally valid scales for measuring physical activity, have been reported in different countries [13].

Grip strength, a practical and clinically significant indicator of muscle strength, provides quick information about general functional status and musculoskeletal involvement. Meta-analysis studies combining normative values for grip strength support the rationale for the widespread use of dynamometer measurements in clinical research [14]. Sleep and Quality of Life: Multidimensional Impact

In the post-disaster period, stress, rumination, environmental conditions, and disruption of daily routines can significantly affect sleep quality and quality of life. Reviews of rumination and exercise approaches accompanying post-disaster stress disorder highlight the psychophysiological effects of physical activity [3]. The PSQI (Pittsburgh Sleep Quality Index), frequently used in the assessment of sleep quality, has established itself as a powerful measurement tool in clinical research, along with its original development work [15]. In the assessment of quality of life, the SF-36 is a frequently used scale to screen health-related quality of life in a multidimensional way; Ware and Sherbourne's fundamental work on the conceptual framework and item selection is one of the scientific foundations of the SF-36 [16]. In addition, studies reporting a positive relationship between recreational physical activities in open spaces and life satisfaction and quality of life suggest that this dimension may be negatively affected in container work conditions [2].

In this context, evaluating allergic reactions, respiratory functions, and related components such as physical activity, sleep, grip strength, and quality of life in individuals working in container-like small spaces in Malatya after the earthquake will fill an important knowledge gap from both clinical and occupational health perspectives.

Objective

The primary objective of this study is to determine the presence and characteristics of allergic reactions and to objectively evaluate respiratory functions (FEV_1 , FVC, FEV_1/FVC) in individuals working in container-like small spaces in Malatya after the February 6, 2023 earthquakes.

Secondary objectives of the study are:

1. To define the levels of physical activity level (IPAQ), sleep quality (PSQI), grip strength, and quality of life (SF-36) in the same sample.
2. To examine whether respiratory functions and other secondary outcomes differ according to the presence of allergic reactions (present/absent or according to subtypes).
3. To statistically investigate possible determinants of respiratory functions and quality of life (physical activity, sleep quality, grip strength, and sociodemographic variables).

Hypotheses

H1: The rate of reporting allergic reactions in individuals working in container-like small spaces is clinically significant.

H2: Individuals reporting allergic reactions have more negative respiratory function (especially FEV_1/FVC) compared to those not reporting allergic reactions.

H3: Lower physical activity levels and worse sleep quality are associated with lower quality of life scores.

H4: Lower grip strength is associated with lower physical functionality and quality of life.

2. Materials and Methods

Study Design

This research is a cross-sectional and descriptive study aiming to evaluate allergic reactions and respiratory functions in individuals working in container-like small areas in Malatya province following the February 6, 2023 earthquakes centered in Kahramanmaraş. The study was planned and conducted in accordance with the principles of the Helsinki Declaration. Study Population and Sample

The study population consists of individuals working in small workplaces in AFAD Malatya Technopark and Rönesans Container City in Malatya province. Volunteers who met the inclusion criteria and had no exclusion criteria were included in the study.

Inclusion Criteria

- Age range 25–55
- At least 2 years of experience working in container-like small spaces
- No diagnosed chronic gastrointestinal or cardiovascular disease
- No communication problems

Exclusion Criteria

- Not being between 25–55 years of age
- Less than 2 years of experience working in container-like small spaces
- Having a diagnosed chronic systemic disease
- Having communication problems

Sample Size

Sample size was determined according to power analysis based on population proportion estimation. Assuming a physical activity level of 20%, the minimum sample size was calculated as 90 individuals with a 95% confidence interval and a 5% margin of error.

Data Collection Tools and Measurements

Data were collected according to standardized measurement protocols and by trained researchers. To increase the objectivity of the evaluations, measurements were performed jointly by at least two researchers.

Sociodemographic and Clinical Information

Sociodemographic and clinical information of the participants, such as age, gender, education level, length of study, and smoking status, were recorded using an evaluation form prepared by the researchers. Evaluation of Allergic Reactions

Participants' history of allergic reactions (allergic rhinitis, dermatitis, asthma-like symptoms, etc.) and triggering factors were questioned through a structured case evaluation form.

Evaluation of Respiratory Functions

Respiratory functions were evaluated using a portable pulmonary function test device. The following parameters were obtained in the measurements:

- Forced expiratory volume (FEV₁)
- Forced vital capacity (FVC)
- FEV₁/FVC ratio

The FEV₁/FVC ratio was used as the basic objective measure in the evaluation of obstructive respiratory disorders.

Physical Activity Level

Individuals' physical activity levels were assessed using the International Physical Activity Questionnaire – Short Form (IPAQ-SF). Participants were classified according to low, moderate, and high physical activity levels.

Sleep Quality

Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI). A total score above 5 was considered poor sleep quality. Grip Strength

To assess upper extremity muscle strength, participants' grip strength was measured using the Valkyrie Digital Wrist Grip Meter. Measurements were taken in three repetitions for each hand, and the highest value was used in the analyses.

Quality of Life

Quality of life was assessed using the Short Form-36 (SF-36) questionnaire. Physical and mental health components were analyzed separately.

Ethical Approval

This study was approved by the Health Sciences Scientific Research Ethics Committee of the Inonu University Scientific Research and Publication Ethics Board (20.05.2025, Session No: 3, Decision No: 2025/4472). The research was conducted in accordance with the principles of the Helsinki Declaration, and written informed consent was obtained from all participants.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics 26.0 software.

- Qualitative data are presented as numbers and percentages (%).
- The distribution of quantitative data was evaluated using the Shapiro–Wilk or Kolmogorov–Smirnov test.
- Data showing a normal distribution are reported as mean ± standard deviation, while those not showing a normal distribution are reported as median (minimum–maximum).
- Independent samples t-test or Mann–Whitney U test was used for two-category qualitative variables.
- One-way analysis of variance (ANOVA) or Kruskal–Wallis test was applied for comparisons involving three or more groups.
- Pearson chi-square, Yates corrected chi-square, or Fisher's exact test was used to analyze relationships between qualitative variables.
- McNemar or Cochran Q tests were applied to analyze dependent qualitative variables.
- In all analyses, a p-value <0.05 was considered statistically significant.

3. Results

A total of 90 participants were included in this cross-sectional study. The sociodemographic characteristics, presence of chronic diseases affecting daily life, level of shortness of breath (mMRC), and recent reports of allergic reactions of the participants are presented in Table 1. The majority of participants were male and actively working individuals; smoking was common, and shortness of breath complaints were present in a specific subgroup (Table 1).

Table 1. Sociodemographic and Clinical Characteristics of Participants (n=90).

Variable	n	%
Gender		
Male	83	92.2
Female	7	7.8
Marital Status		
Single	35	38.9
Married	55	61.1
Number of Children		
0	41	46.1
1	7	7.9
2	21	23.6
3	13	14.6
4	7	7.9
Employment Status		

Unemployed	6	6.7
Employed	83	93.3
Social Security		
No	15	16.9
Yes	74	83.1
Smoking/Alcohol Use		
Neither	27	30.0
Smoking only	46	51.1
Both	14	15.6
Alcohol only	3	3.3
Shortness of breath (mMRC)		
No shortness of breath	58	64.4
Shortness of breath when climbing hills/walking fast	28	31.1
Shortness of breath on flat ground compared to peers	4	4.4
Illness affecting life		
None	75	84.3
Yes	14	15.7
Recent allergic reaction		
No	85	94.4
Yes	5	5

The sample was significantly male-dominated (92.2%), and the vast majority of participants were actively working individuals (93.3%). This suggests that the findings can be generalized primarily to the male population working in small, container-like spaces. Smoking is noteworthy; more than half of the participants reported minimal smoking (smoking only 51.1%; smoking + alcohol 15.6%). According to mMRC assessment, approximately one-third of the participants experienced exertional dyspnea (31.1%), and a small group reported marked dyspnea on a flat surface (4.4%). The rate of recent allergic reaction reporting was low (5.6%); this may limit the statistical power in subgroup analyses based on allergy and requires careful interpretation. Descriptive statistics for anthropometric characteristics, respiratory function, fatigue levels, and muscle strength measurements of the participants are presented in Table 2.

Table 2. Descriptive Statistics of Anthropometric and Clinical Measurements of Participants (n=90).

Variable	Mean ± SD	Median (Min–Max)
Height (cm)	175.19 ± 6.49	175.5 (155–188)
Body weight (kg)	83.01 ± 14.66	82 (44–130)

Body mass index (kg/m ²)	27.01 ± 4.41	26.71 (16.56–40.12)
Age (years)	39.00 ± 9.53	41 (25–55)
Fatigue score	4.09 ± 2.77	4 (0–10)
Handgrip muscle strength (kg)	44.59 ± 8.02	42.4 (31.2–68.7)
FEV1 (L)	2.70 ± 0.67	2.82 (1.19–4.68)
FVC (L)	3.13 ± 0.74	3.19 (1.37–5.16)
FEV1 (%)	68.91 ± 12.40	70 (31–100)
FVC (%)	64.11 ± 11.27	63.5 (29–92)
FEV1/FVC ratio	0.86 ± 0.06	0.87 (0.67–1.00)

The average body mass index of the participants was 27.01 kg/m², indicating that the sample was on the borderline of being overweight. This should be considered an important clinical variable in the interpretation of respiratory functions.

When respiratory function tests were examined, although the absolute values of FEV1 and FVC were generally within the acceptable range, the relatively low values of FEV1% (68.9%) and FVC% (64.1%) suggest a possible tendency towards a subclinical restrictive respiratory pattern in the sample. However, the fact that the FEV1/FVC ratio was maintained (0.86%) indicates that a significant obstructive pattern was not dominant.

The average handgrip strength of 44.6 kg suggests that the participants have a high functional capacity in terms of muscle strength and represent a working population requiring heavy labor. However, the moderate fatigue score may indicate a possible mismatch between physical capacity and perceived fatigue, and the relationship of this to quality of life and respiratory functions should be evaluated with further analysis. Taken together, these findings suggest that while muscle strength is preserved in individuals working in small, container-like spaces, their respiratory function percentages are relatively low, indicating that environmental and ergonomic factors related to the work environment may have early effects on the respiratory system.

Participants' health-related quality of life levels were assessed using the subscale scores of the SF-36 scale, and the results are presented in Table 3.

Table 3. SF-36 Quality of Life Scale Subscale Scores (n=90).

SF-36 Subdimensions	Mean ± SD	Medyan (Min–Max)
Physical Function	80.28 ± 20.74	85 (5–100)
Physical Role Difficulty	85.56 ± 30.67	100 (0–100)
Emotional Role Difficulty	72.22 ± 38.79	100 (0–100)
Energy/Vitality	55.63 ± 24.52	55 (0–100)
Mental Health	45.46 ± 19.57	48.4 (1.2–80.8)
Social Functioning	70.56 ± 23.80	75 (0–100)
Pain	73.57 ± 23.63	77.5 (0–100)
General Health	61.83 ± 17.85	60 (15–100)

When the SF-36 subscale scores were examined, it was observed that participants had high scores in the subscales of physical function (80.3) and physical role difficulty (85.6). This finding indicates that individuals' capacity to perform daily physical activities was generally preserved.

In contrast, relatively low scores were obtained in the subscales of mental health (45.5) and energy/vitality (55.6). This suggests that working in small, container-like spaces may have a more significant negative impact on psychological well-being and subjective energy levels rather than physical functionality.

The moderate-to-high levels of social functioning (70.6) and pain (73.6) subscales indicate that individuals did not experience significant limitations in terms of social life and pain, but that impact in these areas cannot be completely ruled out. The moderate level of general health perception (61.8) suggests that individuals did not fully evaluate their health status as good. When these findings are considered together, it can be said that the physical dimensions of quality of life are relatively preserved in individuals working in small, container-like spaces, but the mental and vitality dimensions are significantly affected. This situation should be evaluated in conjunction with respiratory functions, fatigue, and psychosocial variables in further analyses. Comparisons were made according to the mMRC classification to evaluate the relationship between the participants' subjective levels of shortness of breath and respiratory function tests, and the results are presented in Table 4.

Table 4. Comparison of Respiratory Function Tests According to mMRC Shortness of Breath Level.

Variables	Shortness of Breath Median (Min–Max)	Shortness of Breath on Exertional Use Median (Min–Max)	Shortness of Breath on Flat Surface Median (Min–Max)	p*	η ²
Absent					
FEV1 (L)	2.85 (1.21–4.68)	2.40 (1.19–3.81)	1.81 (1.61–2.99)	0.040	0.072
FVC (L)	3.22 (1.37–5.16)	3.01 (1.37–4.61)	2.14 (1.92–3.45)	0.043	0.071
FEV1 (%)	73.5 (45–95)	63 (44–100)	51.5 (31–53)	<0.001	0.212
FVC (%)	66.5 (43–89)	60 (42–92)	47 (29–52)	<0.001	0.178
FEV1/FVC					
Oranı	0.87 (0.74–1.00)	0.86 (0.67–0.96)	0.85 (0.84–0.87)	0.202	0.036
FEV1 Pre					
Oranı	0.04 (0.02–0.07)	0.04 (0.02–0.05)	0.04 (0.03–0.06)	0.737	0.007
FVC Pre					
Oranı	0.05 (0.02–0.08)	0.05 (0.02–0.09)	0.06 (0.04–0.08)	0.813	0.005

***Kruskal-Wallis test**When comparing pulmonary function tests according to mMRC dyspnea levels, clinically significant and statistically strong differences were found in both absolute and percentage values.

In individuals without dyspnea, FEV1 and FVC values were significantly higher compared to individuals experiencing dyspnea on a flat surface ($p<0.05$). The most striking findings were observed in the percentage of FEV1 and percentage of FVC. The large effect size in these parameters ($\eta^2=0.178\text{--}0.212$) indicates that subjective dyspnea is strongly associated with objective respiratory function loss.

The lack of a significant difference in the FEV1/FVC ratio suggests that dyspnea may be more related to a restrictive pattern or a decrease in overall ventilatory capacity; a distinct obstructive pattern does not appear to be dominant.

These findings reveal that dyspnea complaints in individuals working in small, container-like spaces are not merely a subjective complaint, but are associated with measurable and clinically significant respiratory function losses. This result constitutes the main clinical message of the study. The relationships between pulmonary function tests and demographic, anthropometric

characteristics and quality of life components were evaluated using correlation analysis, and the results are presented in Table 5.

Table 5. Correlations Between Pulmonary Function Tests and Demographic, Anthropometric and Quality of Life Variables.

Variables	Height	Weight	Age	BMI	Hand Muscle Strength	Fatigue	Functional Role	Physical Function	Role Emotional	Role Energy	Mental Health	Social Functioning	Pain	General Health
FEV1 (L)	.377**	0.034	.244*	0.141	0.176	-.211*	.316*	.286**	0.157	-0.021	-0.130	0.032	0.034	0.021
FVC (L)	.392**	0.019	.237*	0.165	0.140	-.221*	.338*	.312**	0.201	-0.010	-0.125	0.067	0.106	0.052
FEV1 (%)	0.178	-0.179	0.106	0.109	0.176	-.229*	.350*	0.097	0.074	0.126	0.032	0.043	-0.016	0.049
FVC (%)	0.243*	.302**	0.175	0.196	.216*	-0.168	0.150	-0.007	0.003	0.013	0.023	0.017	-0.129	0.054
FEV1 Pre-Operative	.656**	0.204	-.376**	0.081	0.065	0.002	0.091	0.144	0.056	-0.177	-0.187	-0.034	0.040	-0.076
FVC Pre-Operative	.617**	.245*	-.354**	0.022	0.002	-0.040	.223*	.214*	0.120	-0.056	-0.179	-0.011	0.142	-0.035

**p<0.01, *p<0.05 (Pearson correlation analysis).

Correlation analysis strongly demonstrates both the biological validity and functional relevance of respiratory function tests.

FEV1 and FVC values showed a significant positive correlation with height (r=0.377 and r=0.392, p<0.001), confirming that spirometric measurements are biologically consistent with anthropometric structure. In contrast, both parameters showed a significant negative correlation with age; this finding reflects the expected physiological decrease in respiratory capacity with age.

The negative correlations between fatigue level and FEV1 and FVC (p<0.05) suggest that subjective fatigue perception increases together with the decrease in respiratory functions. The positive correlations found between physical function and physical role difficulty scores from the SF-36 sub-dimensions and FEV1 and FVC (p<0.01) reveal that respiratory functions are decisive not only physiologically but also in terms of daily living functionality.

The significant negative correlation between FEV1 percentage and fatigue, and the significant positive correlation between FEV1 and physical function; This shows that ventilatory capacity is closely related to perceived performance and functional status. The positive correlation of the FVC

percentage value with handgrip muscle strength suggests a possible physiological link between overall muscle strength and respiratory capacity.

The strong positive correlation of FEV₁ and FVC pre-ratios with height and the strong negative correlation with age is an important finding supporting the technical and biological consistency of the measurements. In addition, the positive relationship of the FVC pre-ratio with physical function and physical role difficulty scores reveals that respiratory functions are directly linked to the physical components of quality of life.

These results show that in individuals working in small container-like spaces, respiratory functions should be considered not only as spirometric parameters but also as fundamental physiological variables determining quality of life and functional capacity.

4. Discussion

This study is a unique research that comprehensively evaluates respiratory functions, quality of life, and functional characteristics in individuals working in container-like small spaces after the February 6, 2023 earthquakes. The main findings showed that although the FEV₁/FVC ratio was largely preserved, the percentage values of FEV₁ and FVC were relatively low. This suggests a decrease in ventilatory capacity or a restrictive tendency rather than a significant airway obstruction [17,18]. It has also been reported in previous studies that obesity and increased body weight can reduce respiratory system compliance by increasing chest wall load and lead to a restrictive pattern, especially with a decrease in FVC [17–19].

In our study, the relationships between anthropometric variables and respiratory functions provide findings that support the biological consistency of spirometric measurements. The positive correlation of FEV₁ and FVC with height is an expected and physiologically significant result in the literature (1,2). The Global Lung Function Initiative (GLI) reference equations identify height as a key predictor of respiratory function [20,21]. However, the negative correlations between age and FEV₁ and FVC are consistent with the literature, reflecting the decrease in lung elasticity and changes in chest wall compliance during aging [22,23].

The relationships between body weight and BMI and respiratory function are more complex. In our study, a negative relationship was found between weight and FVC percentage, while BMI showed a weak or insignificant relationship with most respiratory parameters. This can be attributed to the fact that BMI does not always adequately reflect respiratory mechanics because it cannot distinguish between fat and muscle tissue [21]. It is to be expected that the effect of BMI on respiratory function will be weak, especially in samples consisting of physically active individuals with high muscle strength. This finding suggests that BMI alone may not be a sufficient indicator to explain respiratory function and that more detailed measurements based on body composition should be evaluated in future studies. One of the most striking clinical findings of our study is the significant decrease in FEV₁% and FVC% values as the mMRC dyspnea level increases. The high effect sizes indicate that subjective shortness of breath is strongly associated with objectively measurable respiratory function loss [22]. The lack of significant difference in the FEV₁/FVC ratio between groups suggests that dyspnea may be more related to a restrictive pattern or decreased ventilatory reserve.

An important aspect of the study in small, container-like spaces is the environmental loads related to indoor air quality. Inadequate ventilation is associated with respiratory symptoms, perceived poor air quality, and increased risk of infection [4,5]. It has been reported that indoor humidity imbalances can lead to eye and upper respiratory tract irritation, impaired sleep quality, and respiratory complaints [4]. In particular, building humidity and mold presence are associated with numerous respiratory and allergic effects such as asthma, wheezing, cough, dyspnea, and allergic rhinitis [24,25]. These environmental factors can be considered among the possible explanatory mechanisms of the ventilatory capacity reduction and dyspnea findings observed in our study. In addition, volatile organic compounds (VOCs) released from building and cladding materials and cleaning products in container structures are another important factor creating respiratory risk in the indoor environment. The US Environmental Protection Agency reports that

indoor VOC concentrations can be higher than outdoor concentrations and can lead to both acute and chronic health effects [7]. Recent building environment studies have shown that VOCs released from building materials, especially PVC, increase the risk of inhalation in poorly ventilated areas [26].

Our quality of life findings reveal the psychosocial dimension of working in small, container-like spaces. While the sub-dimensions of physical function and physical role were relatively preserved, the significantly lower sub-dimensions of mental health and vitality suggest that these working environments may have a more negative impact on individuals' psychological well-being and energy levels. It has also been reported in previous studies that mental components are more affected than physical components in individuals after a disaster [16,27,28].

Assessing sleep quality and physical activity levels contributes to a better understanding of this multidimensional impact. PSQI has been shown to be a reliable and valid tool for assessing sleep quality [15]. Similarly, IPAQ is a physical activity measurement tool with proven validity and reliability in different populations [13]. Working in confined spaces can increase sedentary behavior by restricting movement; this can lead to negative effects on fatigue, vitality, and mental health.

When evaluated in terms of musculoskeletal and functional capacity, the high hand grip strength found in our sample suggests that it represents a physically active working group. However, the negative relationship between fatigue and respiratory functions shows that even if peripheral muscle strength is preserved, a decrease in respiratory capacity can increase the symptom burden. The relationship between ergonomic risk factors and musculoskeletal disorders is supported by strong epidemiological evidence [12]. In addition, the relationship of grip strength with functional capacity and general health outcomes is increasingly emphasized in the literature [14,29]. When all these findings are considered together, individuals working in small, container-like spaces face a complex health burden involving decreased respiratory function, dyspnea, impaired mental well-being, and environmental exposures. From a clinical and public health perspective, these results indicate the need for a holistic approach that includes improving ventilation and thermal comfort in work environments, controlling humidity and mold, reducing VOC sources, implementing ergonomic arrangements, active break practices, and early screening approaches (mMRC, spirometry, sleep and activity scales). Such holistic approaches will contribute to improving both respiratory and psychosocial health outcomes in individuals working in confined and enclosed spaces.

5. Conclusions

This study makes a significant contribution to the literature as one of the first comprehensive studies to address respiratory function, quality of life, and functional characteristics together in individuals working in small, container-like spaces after the February 6, 2023 earthquakes. The findings show that these individuals tend to have decreased ventilatory capacity without significant airway obstruction, and that shortness of breath is strongly associated with objectively measurable loss of respiratory function. The study revealed that while physical functions were relatively preserved, mental health and vitality were more significantly affected, indicating that working in small, container-like spaces constitutes not only a physiological but also a psychosocial burden. This suggests that cramped and enclosed work environments can affect individuals' overall health in a multifaceted way.

From a clinical perspective, it is possible to identify at-risk individuals early on in container-like and similar small spaces using simple screening tools (mMRC dyspnea scale, portable spirometry, sleep quality and physical activity questionnaires). This approach can enable the activation of preventive and protective health services before symptoms become apparent. From a public health and occupational health perspective, in container-like work environments;

- Improving ventilation and thermal comfort,
- Preventing humidity and mold formation,
- Reducing exposure to volatile organic compounds from construction and cleaning,
- Making ergonomic arrangements, and

- Encouraging physical activity through active breaks,

are highlighted as fundamental strategies in reducing respiratory and psychosocial impacts. In conclusion, it has been shown that working in container-like small spaces has multifaceted effects on individual health, and these effects should be considered not only clinically but also in conjunction with environmental and organizational factors. These findings provide a scientific basis for policies and practices regarding the planning, organization, and monitoring of temporary work areas after disasters.

6. Strengths And Limitations

Strengths; One of the most important strengths of this study is that it is one of the rare studies that considers respiratory functions, quality of life, and functional parameters together in individuals working in small container-like spaces. In particular, the holistic approach to evaluating the health status of individuals working in temporary work areas after disasters ensures that the study makes a unique contribution to the literature.

The objective evaluation of respiratory functions with portable spirometry in the study allowed for the revelation of physiological effects beyond subjective symptoms. In addition, the classification of the level of shortness of breath with the mMRC scale and the comparison of respiratory functions according to this classification contributed to the production of clinically meaningful and practical results.

The evaluation of quality of life with internationally validated scales such as SF-36, sleep quality with PSQI, and physical activity level with IPAQ increases both the internal validity of the findings and their comparability with different studies. In addition, the inclusion of hand grip strength measurement in the study provided an important perspective on the relationship between respiratory functions and general functional capacity. Another strength is the separate analysis of anthropometric variables (height, weight, and BMI) and the discussion of their physiological relationships with respiratory function. This approach has supported the biological consistency of the measurements and allowed for a more meaningful clinical interpretation of the results.

Limitations; This study has some limitations. First, due to the cross-sectional design of the study, the relationships between variables do not demonstrate causality, but only reflect associations. Therefore, inferences regarding the effects of working in a container environment on respiratory function and quality of life should be interpreted cautiously.

The fact that the study sample consisted largely of male individuals limits the generalizability of the findings to female employees. Similarly, the fact that the vast majority of participants were actively working individuals may have led to insufficient representation of the exposure levels of more vulnerable or non-working groups in this study.

The low rate of allergic reaction reporting limited the statistical power of allergy-based subgroup analyses. This suggests that the true prevalence of allergic exposure may have been underestimated.

The lack of direct measurements of indoor air quality (such as CO₂ level, particulate matter, VOC concentration) resulted in environmental exposures being discussed only indirectly. Simultaneous environmental measurements in future studies will contribute to a stronger mechanistic explanation of the obtained clinical findings. Finally, the lack of direct measurement of body composition (e.g., fat-to-muscle ratio) limited the more detailed analysis of the effect of BMI on respiratory function. This highlights the importance of using methods such as bioelectrical impedance or DEXA in future studies.

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

Data Availability Statement: The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Abbreviations

The following abbreviations are used in this manuscript:

- AFAD – Disaster and Emergency Management Authority (Türkiye)
- ANOVA – Analysis of Variance
- BMI – Body Mass Index
- CO₂ – Carbon Dioxide
- COVID-19 – Coronavirus Disease 2019
- DEXA – Dual-Energy X-ray Absorptiometry
- FEV₁ – Forced Expiratory Volume in 1 Second
- FVC – Forced Vital Capacity
- GOLD – Global Initiative for Chronic Obstructive Lung Disease
- GLI – Global Lung Function Initiative
- IPAQ-SF – International Physical Activity Questionnaire–Short Form
- mMRC – Modified Medical Research Council Dyspnea Scale
- NHANES – National Health and Nutrition Examination Survey
- PSQI – Pittsburgh Sleep Quality Index
- SF-36 – 36-Item Short Form Health Survey
- SNIP – Source Normalized Impact per Paper
- SJR – SCImago Journal Rank
- SPSS – Statistical Package for the Social Sciences
- VOCs – Volatile Organic Compounds
- WHO – World Health Organization

Appendix A

Table A1. Sociodemographic and Clinical Characteristics of Participants (n=90).

Variable	n	%
Gender		
Male	83	92.2
Female	7	7.8
Marital Status		
Single	35	38.9

Married	55	61.1
Number of Children		
0	41	46.1
1	7	7.9
2	21	23.6
3	13	14.6
4	7	7.9
Employment Status		
Unemployed	6	6.7
Employed	83	93.3
Social Security		
No	15	16.9
Yes	74	83.1
Smoking/Alcohol Use		
Neither	27	30.0
Smoking only	46	51.1
Both	14	15.6
Alcohol only	3	3.3
Shortness of breath (mMRC)		
No shortness of breath	58	64.4
Shortness of breath when climbing hills/walking fast	28	31.1
Shortness of breath on flat ground compared to peers	4	4.4
Illness affecting life		
None	75	84.3
Yes	14	15.7
Recent allergic reaction		
No	85	94.4
Yes	5	5

Appendix B

Table A2. Descriptive Statistics of Anthropometric and Clinical Measurements of Participants (n=90).

Variable	Mean ± SD	Median (Min–Max)
Height (cm)	175.19 ± 6.49	175.5 (155–188)
Body weight (kg)	83.01 ± 14.66	82 (44–130)
Body mass index (kg/m²)	27.01 ± 4.41	26.71 (16.56–40.12)
Age (years)	39.00 ± 9.53	41 (25–55)
Fatigue score	4.09 ± 2.77	4 (0–10)
Handgrip muscle strength (kg)	44.59 ± 8.02	42.4 (31.2–68.7)
FEV1 (L)	2.70 ± 0.67	2.82 (1.19–4.68)
FVC (L)	3.13 ± 0.74	3.19 (1.37–5.16)
FEV1 (%)	68.91 ± 12.40	70 (31–100)
FVC (%)	64.11 ± 11.27	63.5 (29–92)
FEV1/FVC ratio	0.86 ± 0.06	0.87 (0.67–1.00)

Appendix C

Table A3. SF-36 Quality of Life Scale Subscale Scores (n=90).

SF-36 Subdimensions	Mean ± SD	Medyan (Min–Maks)
Physical Function	80.28 ± 20.74	85 (5–100)
Physical Role Difficulty	85.56 ± 30.67	100 (0–100)
Emotional Role Difficulty	72.22 ± 38.79	100 (0–100)
Energy/Vitality	55.63 ± 24.52	55 (0–100)
Mental Health	45.46 ± 19.57	48.4 (1.2–80.8)
Social Functioning	70.56 ± 23.80	75 (0–100)
Pain	73.57 ± 23.63	77.5 (0–100)
General Health	61.83 ± 17.85	60 (15–100)

Appendix D

Table A4. Comparison of Respiratory Function Tests According to mMRC Shortness of Breath Level.

Variables	Shortness of Breath Median (Min–Max)	Shortness of Breath on Exertional Use Median (Min–Max)	Shortness of Breath on Flat Surface Median (Min–Max)	p*	η²
Absent					
FEV1 (L)	2.85 (1.21–4.68)	2.40 (1.19–3.81)	1.81 (1.61–2.99)	0.040	0.072

FVC (L)	3.22 (1.37–5.16)	3.01 (1.37–4.61)	2.14 (1.92–3.45)	0.043	0.071
FEV1 (%)	73.5 (45–95)	63 (44–100)	51.5 (31–53)	<0.001	0.212
FVC (%)	66.5 (43–89)	60 (42–92)	47 (29–52)	<0.001	0.178
FEV1/FVC Oranı	0.87 (0.74–1.00)	0.86 (0.67–0.96)	0.85 (0.84–0.87)	0.202	0.036
PreFEV1 Oranı	0.04 (0.02–0.07)	0.04 (0.02–0.05)	0.04 (0.03–0.06)	0.737	0.007
Pre FVC Oranı	0.05 (0.02–0.08)	0.05 (0.02–0.09)	0.06 (0.04–0.08)	0.813	0.005

*Kruskal – Wallis Test.

Appendix E

Table A5. Correlations Between Pulmonary Function Tests and Demographic, Anthropometric and Quality of Life Variables.

Variables	H ei gh t	Weigh t	A ge	BMI	Hand Muscle Strength	Fatigu e	Fun ctio ns	Function s Rol	Role Emoti onal	Role Energ y	Menta l Healt h	Social Function ing	Pain	Gen eral Heal th
EV1 (L)	.377**	0.034	.244*	0.141	0.176	-.211*	.316*	.286**	0.157	-0.021	-0.130	0.032	0.034	0.021
FVC (L)	.392**	0.019	.237*	0.165	0.140	-.221*	.338*	.312**	0.201	-0.010	-0.125	0.067	0.106	0.052
FEV1 (%)	-.0178	-0.179	0.106	0.109	0.176	-.229*	.350*	0.097	0.074	0.126	0.032	0.043	-0.016	0.049
FVC (%)	-.243*	.302**	0.175	0.196	.216*	-0.168	0.150	-0.007	0.003	0.013	0.023	0.017	-0.129	0.054
FEV1 Pre Oranı	.656**	0.204	-.376**	0.081	0.065	0.002	0.091	0.144	0.056	-0.177	-0.187	-0.034	0.040	-.0076

FVC	.2	-												-
Pre	.61	45	-.354**	0.02	0.002	-0.040	.223*	.214*	0.120	-0.056	-0.179	-0.011	0.142	0.03
Oranı	7**	*		2										5

**p<0.01, *p<0.05 (Pearson correlation analysis).

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