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Research Article | Araştırma Makalesi

INVESTIGATION OF THE RELATIONSHIP BETWEEN ERGONOMIC RISK FACTORS, ANTHROPOMETRIC CHARACTERISTICS, AND MUSCULOSKELETAL HEALTH AMONG AMBULANCE WORKERS

AMBULANS ÇALIŞANLARINDA ERGONOMİK RİSK FAKTÖRLERİ, ANTROPOMETRİK ÖZELLİKLER VE KAS İSKELET SAĞLIĞI ARASINDAKİ İLİŞKİNİN İNCELENMESİ

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ABSTRACT

Objective: This study aimed to evaluate the effects of anthropometric characteristics and workplace ergonomic factors on musculoskeletal health of ambulance personnel working in 112 Emergency Medical Services from an occupational health and safety perspective.

Methods: This descriptive cross-sectional study was conducted with 55 ambulance personnel (33 males, 22 females) in Kocaeli, Türkiye. Data were collected using the Personal Information Form, Cornell Musculoskeletal Discomfort Questionnaire (CMDQ), and Ergonomic Evaluation Inventory for Emergency Ambulances (EEIEA). Participants' height, body weight, and upper and lower extremity lengths were measured. Statistical analyses included Kolmogorov-Smirnov and Shapiro-Wilk tests, Mann-Whitney U, Kruskal-Wallis, Dunn's post hoc, and Spearman correlation analyses.

Results: A total of 76.4% of participants perceived their working environment as ergonomically inadequate. CMDQ results showed musculoskeletal complaints were most frequent in the neck, upper back, and spine. Female personnel had significantly higher scores than males in neck, upper back, right shoulder, right wrist, right upper extremity, and total spine regions ($p<0.05$). Although total CMDQ scores were higher in females, the difference was not statistically significant ($p>0.05$). EEIEA results indicated ambulance ergonomic suitability was moderate. No significant correlations were found between anthropometric measurements and CMDQ or EEIEA scores ($p>0.05$).

Conclusion: Ambulance personnel are exposed to considerable ergonomic risks, and inadequate workplace ergonomics may affect musculoskeletal health. Female personnel reported higher discomfort levels than males. These findings emphasize the importance of considering anthropometric characteristics in ambulance design and improving ergonomic conditions. Ergonomic interventions and preventive occupational health and safety strategies are recommended to support employee health and well-being.

Keywords: Emergency medical services, anthropometry, occupational ergonomics, musculoskeletal disorders, occupational safety

ÖZ

Amaç: Bu çalışma, 112 Acil Sağlık Hizmetlerinde görev yapan ambulans çalışanlarının antropometrik özellikleri ile çalışma ortamına ilişkin ergonomik faktörlerin kas-iskelet sistemi sağlığı üzerindeki etkilerini iş sağlığı ve güvenliği perspektifinden değerlendirmek amacıyla gerçekleştirilmiştir.

Yöntem: Tanımlayıcı ve kesitsel tipte planlanan araştırma, Kocaeli'de görev yapan 55 ambulans çalışanı (33 erkek, 22 kadın) ile yürütülmüştür. Veriler, Kişisel Bilgi Formu, Cornell Kas-İskelet Sistemi Rahatsızlık Anketi (CKİSRA) ve Acil Yardım Ambulanslarının Ergonomik Açıdan Değerlendirme Envanteri (AYAEADE) kullanılarak toplanmıştır. Katılımcıların boy uzunluğu, vücut ağırlığı ile üst ve alt ekstremite uzunlukları ölçülmüştür. İstatistiksel analizlerde Kolmogorov-Smirnov ve Shapiro-Wilk normallik testleri, Mann-Whitney U, Kruskal-Wallis, Dunn ve Spearman korelasyon analizleri uygulanmıştır.

Bulgular: Katılımcıların %76,4'ü çalışma ortamını ergonomik açıdan yetersiz olarak değerlendirmiştir. CKİSRA sonuçlarına göre kas-iskelet sistemi yakınmaları en sık boyun, sırt ve omurga bölgelerinde görülmüştür. Kadın çalışanlarda boyun, sırt, sağ omuz, sağ el bileği, sağ üst ekstremite ve omurga toplam skorları erkeklere göre anlamlı düzeyde daha yüksektir ($p<0,05$). Cornell toplam skoru kadınlarda daha yüksek olmasına rağmen fark istatistiksel olarak anlamlı değildir ($p>0,05$). AYAEADE sonuçları ambulansların ergonomik uygunluk düzeyinin orta seviyede olduğunu göstermiştir. Antropometrik ölçümler ile CKİSRA veya AYAEADE puanları arasında anlamlı ilişki saptanmamıştır ($p>0,05$).

Sonuç: Ambulans çalışanlarının önemli ergonomik risklere maruz kaldığı ve çalışma ortamındaki ergonomik yetersizliklerin kas-iskelet sistemi sağlığını olumsuz etkileyebileceği belirlenmiştir. Bulgular, özellikle kadın çalışanların daha yüksek kas-iskelet sistemi yakınmaları bildirdiğini ve ambulans tasarımında çalışanların antropometrik özelliklerinin dikkate alınmasının önemini ortaya koymaktadır. Çalışan sağlığını desteklemek amacıyla ergonomik düzenlemeler ve koruyucu iş sağlığı ve güvenliği uygulamalarının yaygınlaştırılması önerilmektedir.

Anahtar Kelimeler: Acil sağlık hizmetleri, antropometri, iş ergonomisi, kas iskelet sistemi bozuklukları, iş güvenliği

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Introduction

Emergency medical services are recognized by the World Health Organization (WHO) as a comprehensive healthcare system defined under the term "Emergency Medical Services (EMS)," encompassing both the immediate medical intervention initiated at the scene of sudden illness, trauma, or injury, and the safe transport of the patient to an appropriate healthcare facility. The EMS approach encompasses not only acute intervention but also a concept of continuous care that is integrated with all levels of the healthcare system, beginning with the pre-hospital care process. The primary objective of this system is to reduce mortality and morbidity by providing early intervention in life-threatening situations, ensuring patient stabilization, and facilitating the patient's safe and timely transport to an appropriate healthcare facility.[1] In Turkey, emergency medical services are delivered through the 112 EMS system organized under the Ministry of Health; it constitutes a public health service encompassing on-site emergency intervention, patient stabilization, safe patient transport, and pre-hospital care processes. However, EMS are considered one of the most intense and high-risk work environments in the healthcare sector due to the need for rapid decision-making, working under time pressure, physically demanding procedures, and a high workload.[2] Owing to the time pressure, high workload, uncontrolled environmental conditions, and the need for immediate intervention inherent in the field, EMS is considered one of the most physically and psychologically challenging areas of employment in the healthcare sector. Ambulance workers are constantly exposed to ergonomic stressors due to reasons such as patient lifting and transport, performing medical interventions in narrow and confined spaces, working in awkward postures, performing duties within a long-shift system, and providing services in moving vehicles.[3,4] In particular, the confined nature of ambulance interiors forces staff to repeatedly perform biomechanically risky movements such as bending, twisting, reaching, squatting, and remaining in static positions for extended periods; this creates significant physical stress on the musculoskeletal system.[5] Furthermore, within the dynamic environment of ambulance services, high noise levels from sirens, vehicle vibration, the risk of traffic accidents, exposure to infectious agents, and intense psychosocial stress factors are among the major occupational risks that affect worker health in multiple dimensions. It has been documented that long-term exposure to these risks can have a negative impact on workers' physical performance, occupational productivity, and quality of life.[6]

Ergonomics is an interdisciplinary science that addresses the arrangement of the work environment to suit human anatomical, physical, cognitive, and physiological characteristics.[7] The fundamental principle of the ergonomic approach is to adapt the work and working conditions to the human's capabilities and limitations, rather than expecting the human to adapt to the work.[8] Recent intervention studies further support the importance of ergonomics-based approaches, showing that ergonomic training combined with exercise may reduce musculoskeletal pain and improve functionality among workers exposed to occupational physical demands.[9,10] In this regard, anthropometric measurements play a crucial role in ensuring that work areas, equipment, and vehicle interiors are designed to suit the physical characteristics of workers.[11] The presence of anthropometric inconsistencies in ambulance interiors forces employees to reach beyond their comfortable range, increases the likelihood of improper work postures, and creates additional biomechanical stress on the musculoskeletal system.[12] In addition, the fact that workers of varying heights and body measurements are required to perform their duties within the same standard vehicle interior layout and equipment configuration leads to more pronounced ergonomic risks.[13] It has been reported that ambulance workers are among the occupational groups with the highest risk of musculoskeletal disorders in the healthcare sector. Similar occupational health studies conducted in healthcare and physically demanding work settings have also shown that musculoskeletal disorders are closely associated with repetitive movements, awkward postures, prolonged constrained positions, and intensive physical workload.[14,15] Musculoskeletal complaints, particularly in the lower back, neck, upper back, and shoulder regions, have been indicated to be prevalent among ambulance personnel.[16] It is highlighted that the main contributing factors to the onset of these conditions include physically demanding tasks such as patient lifting and transport, stretcher transfers, the use of heavy equipment, and repetitive physical exertion.[17,18] In terms of occupational health and safety, it has been reported that the ergonomic risks faced by ambulance workers not only cause individual health problems but also lead to a decrease in work efficiency, loss of workforce, an increase in occupational diseases, and significant consequences for patient safety.[19] Therefore, identifying ergonomic risks, integrating anthropometric data into workplace design, and developing measures to protect worker health have been recognized as key components of occupational health and safety practices in EMS.[20] Although previous studies have extensively investigated ergonomic risk factors, work-related musculoskeletal disorders, and occupational health and safety issues among ambulance personnel, these factors have generally been evaluated independently. Existing research has primarily focused on the prevalence of musculoskeletal complaints, biomechanical demands of patient handling, or ergonomic characteristics of ambulance work environments. Recent studies have mostly examined musculoskeletal pain and ergonomic interventions in specific occupational groups, whereas integrated evidence addressing ambulance workers' anthropometric characteristics, ergonomic risk exposure, and musculoskeletal health together remains limited.[9,14,15] However, studies simultaneously examining anthropometric characteristics, workplace ergonomics,

and musculoskeletal health within the same occupational health and safety framework remain limited. Considering that anthropometric compatibility may influence workers' interaction with the ambulance environment and equipment, a more integrated evaluation of these factors may contribute to a better understanding of occupational risks among ambulance personnel. In particular, the lack of sufficient studies in the literature that jointly address the relationship between anthropometric fit, ergonomic risk factors, and musculoskeletal disorders among 112 Emergency Health Services staff highlights the necessity of this research.

Previous studies have reported sex-related differences in anthropometric characteristics, physical workload tolerance, and the prevalence of musculoskeletal disorders among healthcare workers and emergency medical service personnel. Considering that ambulance work environments are standardized despite variations in worker characteristics, evaluating potential differences between male and female personnel may contribute to a better understanding of ergonomic risks and musculoskeletal health outcomes in this occupational setting. The purpose of our study is to comprehensively evaluate the effects of anthropometric characteristics and workplace-related ergonomic risk factors on musculoskeletal health among ambulance workers in the EMS, in line with the occupational health and safety perspective. In this scope, the study sought to examine the ergonomics of ambulance work environments, identify the relationship between anthropometric characteristics and musculoskeletal disorders, and develop recommendations that could contribute to occupational health and safety practices aimed at protecting worker health based on the findings.

Methods

Our study was designed and conducted as a descriptive, cross-sectional study to evaluate the effects of ambulance workers' anthropometric characteristics and workplace ergonomic factors on musculoskeletal health. Our investigation was conducted at stations 112 EMS which operate in Kocaeli Province, and data were collected between January 2026 and April 2026. The study universe consisted of healthcare personnel actively performing duties within the 112 EMS in Kocaeli Province, while the sample comprised a total of 55 healthcare workers who met the specified inclusion criteria and voluntarily agreed to participate in the study. Of the participants, 33 (60%) were male and 22 (40%) were female healthcare workers. In our research, eligible participants were identified through 112 EMS stations operating within the study region. During the data collection period, healthcare personnel who met the inclusion criteria were informed about the purpose and procedures of the study by the researchers and were invited to participate on a voluntary basis. Individuals who agreed to participate and provided written informed consent were enrolled in the study. The sample size was determined based on a power analysis conducted using G*Power version 3.1.9.7. The expected effect size was estimated according to the findings reported, which investigated musculoskeletal health and ergonomic factors among ambulance personnel.[17] Assuming an alpha level of 0.05, a statistical power of 95%, and an anticipated correlation coefficient of r=0.50, the minimum required sample size was calculated as 46 participants. To account for potential data loss and incomplete responses, 55 participants were included in the study.

The inclusion criteria were being actively employed at 112 EMS stations in Kocaeli Province, being 18 years of age or older, providing written informed consent by voluntarily agreeing to participate in the study, and actively continuing professional duties during the data collection period. The exclusion criteria were pregnancy or the early postpartum period, a history of chronic musculoskeletal disorders, having experienced a serious musculoskeletal injury or undergone a surgical intervention within the previous six months, and incomplete completion of the data collection instruments. In addition, institutional permission was granted by the Kocaeli Emergency Health Services Directorate under the Kocaeli Provincial Health Directorate on 25.12.2025. Necessary permissions were obtained for the use of the assessment instruments, and all participants were informed about the study and provided written informed consent prior to participation. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki.

Data collection tools

Data were collected using a Personal Information Form developed by the researchers, the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ), and the Ergonomic Evaluation Inventory of Emergency Aid Ambulances (EEIEAA). In addition, anthropometric measurements of the participants were obtained in accordance with standard anthropometric measurement procedures. The Personal Information Form (PIF) was designed by the researchers to obtain sociodemographic and occupational characteristics of the participants and included information regarding age, sex, educational status, professional title, years of professional experience, smoking and alcohol consumption, regular exercise habits, occupational health and safety training, and history of work-related accidents. The CMDQ was used to assess musculoskeletal complaints experienced by the participants during the previous week. The CMDQ is a self-report instrument that evaluates the frequency and severity of discomfort as well as its impact on daily activities and work performance across different anatomical regions, including the neck, back, lower back, and upper and lower extremities. For each body region, the frequency of discomfort, pain severity, and the degree of interference with work or daily activities are scored separately, and a total score is calculated by multiplying these parameters. Higher scores indicate a greater level of musculoskeletal discomfort. The Turkish

validity and reliability study of the questionnaire was previoulsy conducted, who reported a Cronbach's alpha coefficient ranging from 0.87 to 0.89.[22]

The EEIEAA was used to assess the ergonomic suitability of the ambulance working environment. The EEIEAA is a comprehensive assessment instrument that enables a multidimensional evaluation of ergonomic conditions within ambulance settings. The EEIEAA was developed by Çan et al. to evaluate the ergonomic suitability of emergency aid ambulances through a multidimensional assessment approach. During the scale development study, the content validity of the inventory was established through expert evaluation, and satisfactory internal consistency coefficients were reported for the overall scale and its subdimensions. The inventory has been shown to be a valid and reliable instrument for assessing ergonomic conditions in ambulance environments and has been used to identify ergonomic risks that may affect healthcare personnel working in prehospital emergency services.[23] The inventory consists of 48 items and comprises four subscales: "General Cabin Characteristics," "Stretcher and Stabilization Equipment," "Medical Devices and Equipment," and "Personnel Safety." The inventory is rated on a 5-point Likert scale, with higher scores indicating a greater level of ergonomic suitability within the ambulance work environment.[23]

Anthropometric measurements

As scope of the anthropometric assessment, measurements of height, body weight, upper extremity length, and lower extremity length were obtained. Height was measured using a measuring tape while participants were standing in the standard anatomical position. Body weight was assessed using a digital scale with a precision of 0.1 kg, with participants wearing light clothing. Body Mass Index (BMI) was calculated using the recorded height and body weight measurements (World Health Organization, 2019). Upper extremity length was determined by measuring the linear distance between the acromion and the dactylion, the distal tip of the third finger, and was recorded in centimeters. Lower extremity length was assessed by measuring the linear distance between the anterior superior iliac spine (ASIS) and the medial malleolus. To ensure measurement consistency and standardization, all anthropometric assessments were performed by the same researchers.

Data collection

Investigation's data were collected by the researchers through face-to-face administration of the study instruments. Prior to data collection, participants were provided with detailed information regarding the purpose, scope, and procedures of the study, and written informed consent was obtained from all individuals who agreed to participate. During the data collection process, the PIF and the study questionnaires were administered first, followed by anthropometric assessments conducted in accordance with standardized measurement protocols. Completion of the questionnaires required approximately 15-20 minutes, and all anthropometric measurements were obtained during the same session. Throughout the study, particular attention was paid to maintaining measurement standardization and ensuring the confidentiality of participant information.

Statistical analysis

Statistical analyses of the study data were performed using IBM SPSS Statistics version 29.0 (IBM Corp., Armonk, NY, USA). The normality of data distribution was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Continuous variables with a normal distribution were expressed as mean ± standard deviation, whereas non-normally distributed continuous variables were presented as median (25th-75th percentile). Categorical variables were reported as frequencies (n) and percentages (%). For comparisons between groups, the Mann-Whitney U test was used for non-normally distributed variables involving two independent groups, while the Kruskal-Wallis test was applied for comparisons involving more than two groups. When a statistically significant difference was detected in the Kruskal-Wallis analysis, Dunn's post hoc multiple comparison test was performed to identify the source of the difference. Associations between continuous variables were evaluated using Spearman's correlation analysis. A p-value of <0.05 was considered statistically significant for all analyses.

Results

For evaluation of years of service in EMS, 58.2% of the participants had 10 years or more of professional experience, followed by those with 1-5 years (23.6%) and 5-10 years (18.2%) of experience. While 16.4% of the participants reported having a diagnosed musculoskeletal disorder, 83.6% reported no such diagnosis. The proportion of participants who experienced a work-related accident during duty within the previous year was 14.5%, whereas 85.5% reported no history of work-related accidents. Only 23.6% of the participants considered the working environment (ambulance and station) adequate in terms of ergonomic and safe working conditions, while the majority ot them (76.4%) perceived the existing working conditions as inadequate. The BMI of the participants was calculated as 25.99 ± 2.68 kg/m² (Table 1).

According to the CMDQ results, female participants had significantly higher neck, back, and total spinal scores compared with male participants ($p<0.05$). Similarly, scores for the right shoulder, right wrist, and right upper extremity were significantly higher among female participants. In contrast, no statistically significant sex-related differences were observed in CMDQ scores for the lower extremity regions. Analysis of the total Cornell scores revealed that the median total score was higher in female participants than in male participants; however,

this difference did not reach statistical significance (p>0.05) (Table 2, Figure 1).

When the anthropometric measurements and CMDQ scores of the participants were examined, the median upper extremity length was found to be 72.00 cm (25th-75th percentile: 68.00-74.00), while the median lower extremity length was 91.00 cm (25th-75th percentile: 88.00-93.00). The mean BMI of the participants was calculated as 26.12 ± 2.68 kg/m². Within the CMDQ, evaluation of the spinal regions showed that the median scores for the neck, back, and lower back regions were 0.00, 1.50, and 1.50, respectively, whereas the median total spinal score was 4.50. In the assessment of the upper extremity regions, median values were largely 0.00 for the right and left shoulders, upper arms, forearms, and wrists, and the median total scores for the right and left upper extremities were 0.00 and 0.00, respectively. Examination of the lower extremity regions revealed that the scores for the hip, upper leg, knee, lower leg, and foot regions generally had median values of 0.00. The median total scores for the right and left lower extremities were calculated as 1.50. Evaluation of the total Cornell score demonstrated that the median total score of the participants was 12.00 (25th-75th percentile: 3.00-86.00) (Table 3).

Table 1. Distribution of participants by demographic variables (n=55)

Variables	
Gender, n (%)	
Female	22 (40)
Male	33 (60)
Ages, n (%)	
18-29 years	17 (30.9)
30 years and older	38 (69.1)
Years of working in 112, n (%)	
1-5 years	13 (23.6)
5-10 years	10 (18.2)
10 years and older	32 (58.2)
Any Diagnosis Related to Musculoskeletal System?	
Yes	9 (16.4)
No	46 (83.6)
Have you attended any occupational health and safety training at your organization in last year?	
Yes	29 (52.7)
No	26 (47.3)
Have you experienced any work-related accidents (falls, collisions, injuries, etc.) during the past year?	
Yes	8 (14.5)
No	47 (85.5)
Do you think your daily work environment (ambulance, station) provides adequate ergonomic and safe working conditions?	
Yes	13 (23.6)
No	42 (76.4)
BMI, Mean ± SD	25.99 ± 2.68

Table 2. Comparative analysis of CMDQ scores based on gender subvariable.

Variables	**Median (25th-75th Percentile)**	**p value**
Neck		
Male (n=33)	0.00 (0.00-1.50)	0.012*
Female (n=22)	3.50 (0.00-14.00)	
Back		
Male (n=33)	1.50 (0.00-3.25)	0.021*
Female (n=22)	3.50 (1.12-20.25)	
Total Spine Score (Neck + Back + Lower Back)		
Male (n=33)	3.00 (1.50-10)	0.019*
Female (n=22)	12.25 (3.37-74.00)	
Right Shoulder		
Male (n=33)	0.00 (0.00-0.75)	0.014*
Female (n=22)	1.50 (0.00-15.50)	
Right Wrist		
Male (n=33)	0.00 (0.00-0.00)	0.017*
Female (n=22)	0.00 (0.00-1.50)	
Right Upper Extremity		
Male (n=33)	0.00 (0.00-3.00)	0.007*
Female (n=22)	4.00 (0.00-20.37)	
Total Cornell		
Male (n=33)	9.00 (3.00-36.75)	0.100
Female (n=22)	28.50 (6.37-128.12)	

* This symbol indicates p<0.05.

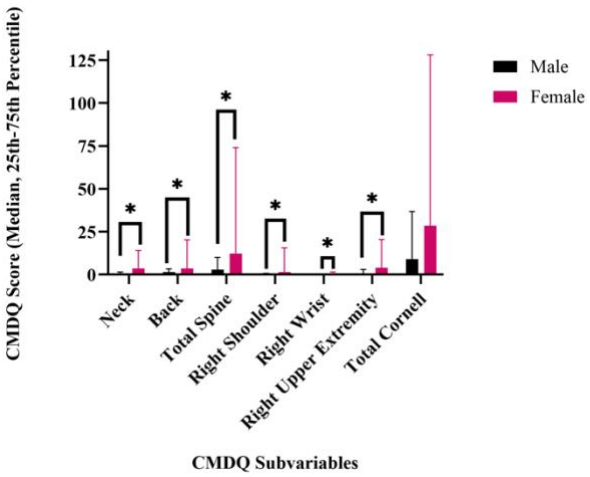

Figure 1. Comparison of CMDQ subvariable scores between male and female participants. * indicates p<0.05.

When the EEIEAA subscale scores were examined, the median score of the cabin subscale was 49.00 (25th-75th percentile: 44.00-53.00), whereas the median score of the medical devices and equipment subscale was 44.00 (25th-75th percentile: 39.00-52.00). While the median score of the personnel safety subscale was calculated as 27.00 (25th-75th percentile: 23.00-31.00), the median score of the Stretcher and Stabilization Equipment

subscale was found to be 44.00 (25th-75th percentile: 36.00-50.00). For evaluation of the total EEIEAA score, the median total score of the participants was found to be 163.00 (25th-75th percentile: 142.00-186.00) (Table 4). In addition, Spearman's correlation analyses were performed to examine the relationships between anthropometric characteristics (BMI, upper extremity length, and lower extremity length) and musculoskeletal discomfort and ergonomic assessment scores. No statistically significant correlations were identified between anthropometric measurements and CMDQ total scores or EEIEAA total scores ($p>0.05$).

Table 3. Descriptive statistics on participants' anthropometric measurements, BMI, and CMDQ scores.

Variables, n=55	
BMI, Mean ± SD	26.12 ±2.68
	Median (25th-75th Percentile)
Anthropometric Measurements	
Upper Extremity Length	72.00 (68.00-74.00)
Lover Extremity Length	91.00 (88.00-93.00)
CMDQ Scores	
Neck	0.00 (0.00-3.50)
Back	1.50 (0.00-7.00)
Lower Back	1.50 (0.00-14.00)
Total Spine Score (Neck+Back+Lower Back)	4.50 (3.00-29.50)
Right Shoulder	0,00 (0.00-3.00)
Right Upper Arm	0.00 (0.00-1.50)
Right Forearm	0.00 (0.00-0.00)
Right Wrist	0.00 (0.00-0.00)
Right Upper Extremity	0.00 (0.00-5.00)
Left Shoulder	0.00 (0.00-1.50)
Left Upper Arm	0.00 (0.00-0.00)
Left Forearm	0.00 (0.00-0.00)
Left Wrist	0.00 (0.00-0,00)
Left Upper Extremity	0.00 (0.00-3.00)
Right Hip	0.00 (0.00-3.00)
Right Thigh	0.00 (0.00-1.50)
Right Knee	0.00 (0.00-1.50)
Right Lower Leg	0.00 (0.00-0.00)
Right Foot	0.00 (0.00-0.00)
Right Lower Limb	1.50 (0.00-7.00)
Left Hip	0.00 (0.00-3.00)
Left Thigh	0.00 (0.00-0.00)
Left Knee	0.00 (0.00-1.50)
Left Lower Leg	0.00 (0.00-0.00)
Left Foot	0.00 (0.00-0.00)
Left Lower Limb	1.50 (0.00-7.00)
Cornell Total	12.00 (3.00-86.00)

Table 4. Descriptive statistics for the EEIEAA subscale and total scores

Variables (n=55)	**Median (25th-75th Percentile)**
Total Cabin	49.00 (44.00-53.00)
Total Medical Devices and Supplies	44.00 (39.00-52.00)
Total Staff Safety	27.00 (23.00-31.00)
Total EEIEAA	163.00 (142.00-186.00)
Total Stretchers and Other Equipment	44.00 (36.00-50.00)

Discussion

The descriptive findings obtained in the present study indicated a noteworthy relationship between the demographic characteristics, working conditions, occupational risk levels, and musculoskeletal health of ambulance workers employed in EMS (Table 1). The fact that 60% of the participants were male, 40% were female, and that the majority of the sample (69.1%) consisted of individuals aged 30 years and older suggested that the study population was predominantly composed of adult healthcare professionals with substantial occupational experience. In particular, the finding that 58.2% of the participants had 10 years or more of professional experience might be considered an important indicator of prolonged exposure to physical workload and repetitive occupational strain among ambulance workers. It is well recognized that ambulance personnel routinely perform physically demanding tasks throughout their professional careers, including patient handling, stretcher transfers, emergency interventions, and working in awkward postures. Scientists have reported that such repetitive physical demands could contribute to the development of musculoskeletal disorders through cumulative trauma over time.24 Furthermore, prolonged years of service may not only increase the duration of physical loading but also contribute to the chronicity of biomechanical stress. Accordingly, the high proportion of participants with extensive professional experience in the our research might be regarded as an important factor supporting the potential association between the musculoskeletal findings and long-term occupational exposure.

The anthropometric findings of the our investigation demonstrated median upper and lower extremity lengths of 72 cm and 91 cm, respectively (Table 3). These findings indicated that consideration of the physical characteristics of ambulance workers in the design of the working environment was crucial for achieving ergonomic compatibility. In confined and mobile workspaces such as ambulance cabins, anthropometric characteristics constitute key determinants of equipment accessibility, working posture, and effective utilization of the available workspace.[25] The requirement for workers with different extremity lengths to perform their duties

within the same standardized work environment may lead to ergonomic incompatibilities, particularly with respect to equipment access and working positions. Such incompatibilities may increase the biomechanical load imposed on the musculoskeletal system over time. In the present study, the mean BMI of the participants was 26.12±2.68 kg/m², indicating that the study population was generally close to the overweight range (Table 3). Elevated BMI values may represent an important risk factor for worker health, particularly in physically demanding work environments such as ambulances.

One of the notable findings of our study was that 76.4% of the participants considered their working environment inadequate in terms of ergonomic and safe working conditions. This finding was consistent with previous reports suggesting that ambulance work environments are ergonomically inadequate. Musculoskeletal injuries have been reported to occur more frequently among ambulance workers than among other healthcare professionals working in hospital settings, and ergonomic inadequacies have been identified as one of the major contributing factors to this situation.[26] In particular, the limited physical space of ambulance cabins, inappropriate equipment placement, and structural characteristics restricting workers' mobility may contribute to increased biomechanical loading during duty. The fact that the majority of the participants of the present study perceived their current working conditions as inadequate suggested that anthropometric compatibility, reach distances, and workspace planning may not have been sufficiently considered in ambulance interior design. In addition, current designs appeared to have been developed primarily according to technical standards rather than the physical requirements of workers. This finding was considered important as it highlighted the limited implementation of a human-centered ergonomic design approach in practice. Furthermore, 14.5% of the participants reported experiencing a work-related accident during duty within the previous year, supporting the notion that EMS represents a high-risk occupational setting. The performing interventions in a moving ambulance, working within a confined space, and exposure to sudden vehicle movements increase the risk of falls, collisions, and injuries. Moreover, the finding that 16.4% of the participants had a diagnosed musculoskeletal disorder indicated that occupational exposure may lead not only to musculoskeletal complaints but also to clinically significant health problems (Table 1).

Evaluation of the CMDQ findings revealed that the scores related to the spinal regions were particularly noteworthy. The median total spinal score, which comprised the combined scores of the neck, back, and lower back regions, was 4.50, suggesting that ambulance workers were exposed to a considerable degree of physical loading in the spinal region (Table 3). Previous studies have reported that musculoskeletal complaints among ambulance workers are most frequently concentrated in the neck, back, and lower back regions.[27] Patient handling, stretcher transfer, and performing interventions in moving vehicles have been shown to impose substantial biomechanical stress on the spine.[28,29] In addition, the frequent repetition of bending, twisting, and lifting movements during duty has been considered an important factor contributing to spinal loading among ambulance workers. This interpretation is supported by recent evidence showing that repetitive tasks, static postures, and physically demanding work activities are associated with musculoskeletal pain, particularly in the neck, back, lower back, and upper extremity regions.[14,15] Although low median values were observed for most upper extremity regions, the total score for the right upper extremity was higher than that of the left side (Table 3). This finding may be associated with the more intensive use of the dominant hand among workers. Repetitive upper extremity movements have been reported to increase physical strain, particularly in the shoulder, forearm, and wrist regions among ambulance workers.[30] The active and continuous use of the upper extremities during stretcher handling, patient transportation, and equipment operation may further contribute to increased loading in these regions. The generally lower scores observed for the lower extremity regions suggested that physical loading among ambulance workers was concentrated predominantly in the upper body (Table 3). Nevertheless, the fact that total lower extremity scores were not completely absent indicated that the lower extremities were also subjected to loading during prolonged standing, maintaining balance in moving vehicles, and patient-handling activities. Previous studies have reported that ambulance workers may experience biomechanical strain in the lower extremities due to irregular surfaces, sudden maneuvers, and the continuous movement demands of their working environment.[30] Other scientists have been also reported that the lower extremities, together with the spine, are exposed to substantial postural loading during patient transfer procedures.[30]

Sex-based analysis of the CMDQ findings demonstrated that female participants had significantly higher scores in the neck, back, right shoulder, right wrist, and right upper extremity regions than male participants (Table 2, Figure 1). In addition, the total spinal score, representing the combined scores of the neck, back, and lower back regions, was significantly higher among women ($p<0.05$), suggesting that female workers may be more affected by occupational physical loading. These findings were consistent with previous reports in the literature. A significantly higher prevalence of musculoskeletal disorders, particularly those involving the neck and back region, among female EMS workers compared with male workers has been also reported in the particular country.[31] These findings support the higher neck and total spinal scores observed among female participants in our study. The higher scores observed in the neck, back, and upper extremity regions among female workers may be explained by the relationship between the working environment and anthropometric compatibility. Since ambulance equipment layouts are generally designed according to standardized

dimensions, workers with shorter extremity lengths may be required to perform greater reaching, bending, and twisting movements when accessing equipment. Such conditions may increase biomechanical loading through the adoption of awkward postures. Likewise, musculoskeletal complaints among ambulance workers have been shown to be concentrated most frequently in the spinal and upper extremity regions.[32] It has also been emphasized that repetitive bending, twisting, and reaching movements performed during duty may result in musculoskeletal symptoms of clinical significance.26 In our study, the higher right shoulder, right wrist, and total right upper extremity scores observed among female participants ($p<0.05$) may be associated with the intensive use of the upper extremities during work activities. Repetitive physical loading frequently occurs in the shoulder and wrist regions during stretcher handling, equipment use, and patient care procedures. Substantial physical loads on both the upper extremities and the spine during patient-handling tasks among EMS personnel have been reported, and the importance of ergonomic equipment in reducing these loads has been highlighted.[4]

The median total Cornell score of 12.00 observed in our study indicated that musculoskeletal disorders were prevalent to a certain extent among ambulance workers (Table 3). Previous studies have consistently emphasized that ambulance workers are at a high risk of developing musculoskeletal disorders due to heavy lifting, awkward postures, repetitive movements, and prolonged working hours.[33] In particular, the physical demands associated with patient handling and stretcher transfer have been reported to contribute to chronic strain in the spinal and upper extremity regions. Therefore, improving the ergonomic conditions of ambulance work environments, promoting the use of equipment designed to reduce physical loading, and implementing preventive ergonomic interventions appear to be of considerable importance. Recent randomized controlled studies have shown that ergonomic training combined with exercise-based approaches can reduce pain intensity, improve functionality, and support worker well-being in occupational groups exposed to physical workload.[9,10]

The generally moderate EEIEAA subscale scores and the median total score of 163.00 suggested that ambulances may not fully meet workers' ergonomic expectations (Table 4). This finding further suggested that current ambulance interior designs may not be sufficiently optimized with respect to workers' physical requirements and operational demands. The compatibility between the ambulance environment, equipment, and healthcare personnel has been identified as one of the fundamental determinants of work efficiency, worker safety, and ergonomic suitability, and workers' perceptions have been emphasized as an important component in evaluating this compatibility.[23,25] The EEIEAA findings obtained in our study clearly highlighted the importance of adopting a human-centered ergonomic approach in ambulance design. Reorganizing ambulance interiors according to workers' anthropometric characteristics, positioning equipment in accordance with reach envelope principles, and implementing automatic or hydraulic systems to reduce manual loading may contribute not only to the protection of worker health but also to the quality of EMS delivery. Consequently, ergonomic design processes should be developed on the basis of user experience and the physical demands of the working environment rather than relying solely on technical standards.

In this study, the anthropometric characteristics, ergonomic risk factors, and musculoskeletal disorders of ambulance workers employed in EMS were evaluated from an occupational health and safety perspective. The findings demonstrated that ambulance workers were exposed to considerable physical loading, particularly in the spinal and upper extremity regions, and that current working conditions involve important ergonomic limitations. The higher CMDQ scores observed among female workers in the neck, back, and upper extremity regions further supported the influence of the relationship between workplace design and anthropometric compatibility on worker health. Moreover, the fact that the majority of participants did not perceive the ambulance environment as ergonomic and safe suggested that current ambulance designs may not be adequately optimized in terms of user requirements, working postures, and available workspace. The EEIEAA findings also indicated that ambulance interior designs may not fully accommodate workers' physical characteristics and operational demands, and that confined workspaces, equipment layout, and tasks requiring manual loading may impose additional biomechanical stress on the musculoskeletal system. Furthermore, the higher CMDQ scores observed among workers who had experienced occupational accidents suggested that ergonomic inadequacies may affect not only worker comfort but also occupational safety and health outcomes. Based on these findings, ambulance work environments should be re-evaluated from an ergonomic perspective. Consideration of workers' anthropometric characteristics in ambulance design, optimization of equipment placement to facilitate accessibility, and implementation of ergonomic modifications aimed at reducing physical loading are recommended. In particular, redesigning stretcher systems, patient-handling equipment, and fixed medical devices according to user-centered ergonomic principles may contribute to the protection of worker health and the reduction of occupational injuries. In addition, regular ergonomics training programs, early screening strategies for musculoskeletal disorders, and preventive approaches aimed at maintaining physical fitness should be promoted among ambulance workers. This recommendation is consistent with recent intervention studies emphasizing that preventive workplace strategies, including ergonomics training and exercise programs, may contribute to reducing musculoskeletal complaints and improving functional outcomes among workers.[9,10,15] Future studies involving larger samples from different regions, the use of objective ergonomic

assessment methods, and longitudinal follow-up designs may provide a more comprehensive understanding of the relationship between ambulance ergonomics, anthropometric characteristics, and musculoskeletal health.

Limitations and future perspectives

This study should be interpreted in light of its cross-sectional design. The findings reflect the ergonomic conditions, anthropometric characteristics, and musculoskeletal health status of ambulance workers during the study period. Furthermore, anthropometric evaluation was restricted to selected measurements considered relevant to the study objectives. Despite these considerations, the study provides a comprehensive assessment of workplace ergonomics, anthropometric characteristics, and musculoskeletal health among ambulance personnel from an occupational health and safety perspective. Future studies involving larger and more diverse samples may further enhance understanding of the relationship between workplace ergonomics, anthropometric characteristics, and musculoskeletal health among ambulance personnel. In addition, the use of objective ergonomic assessment methods and longitudinal study designs may provide a more comprehensive evaluation of occupational risk factors. From a practical perspective, ergonomic improvements in ambulance design, equipment placement, and patient-handling systems should be considered to support worker health and safety.

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Compliance with Ethical Standards

Ethical approval for the study was obtained from the Non-Interventional Ethics Committee of Kocaeli Health and Technology University, Kocaeli, Türkiye (Decision No: 2025/184; Date: 08.09.2025).

Conflict of Interest

The authors declared no potential conflict of insterest.

Author Contributions

SD, Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing-original draft;
BK, Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Supervision, Validation, Writing-original draft, Writing-review & editing.

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