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# Age-Specific Determinants of Musculoskeletal Disorders: A Comparative Mixed-Methods Study of Sedentary Behaviour and Physical Activity in Young and Adult Bahraini Women

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## Abstract

Musculoskeletal disorders (MSDs) represent a growing public health concern, particularly among women experiencing lifestyle shifts due to occupational and technological demands. This study examined age-related differences in MSD prevalence and determinants among Bahraini women using a convergent parallel mixed-methods design. Quantitative data were collected from 300 participants (150 young: 18–25 years; 150 adult: 30–50 years) using the Nordic Musculoskeletal Questionnaire (NMQ) and the International Physical Activity Questionnaire–Short Form (IPAQ-SF). Complementary semi-structured interviews (n = 25) explored psychosocial and cultural influences on behaviour and pain perception. Results revealed a 12-month MSD prevalence of 62.7%, with lower back and neck pain most frequently reported. Adult women exhibited higher body mass index (BMI), longer sedentary time, and greater knee pain, whereas younger women reported more wrist and neck discomfort, likely linked to digital device use. Regression analyses confirmed that sedentary behaviour positively predicted MSD severity ($\beta = 0.41$, $p < 0.001$), while physical activity exerted a protective effect ($\beta = -0.29$, $p = 0.002$). Age significantly moderated the sedentary–pain relationship ($\beta = 0.17$, $p = 0.03$). Thematic analysis identified four core themes: (1) sedentary lifestyle as the norm, (2) social and cultural constraints, (3) pain ignored until severe, and (4) limited awareness of protective exercise. Integration of quantitative and qualitative findings revealed age- and context-specific mechanisms underlying MSD risk. The study underscores the need for interventions promoting digital ergonomics, workplace mobility, and culturally tailored awareness programs to reduce MSD burden among women in the Gulf region.

**Keywords:** Musculoskeletal disorders; sedentary behaviour; physical activity; ergonomic awareness; Bahraini women; mixed-methods; public health prevention, Bahraini women, physical activity among Bahraini women

## Introduction

Musculoskeletal disorders (MSDs) have emerged as a leading cause of disability and impaired functional performance globally, particularly among women whose biological, occupational, and lifestyle factors place them at elevated risk (7). These disorders represent a multifactorial health concern that intersects physical, psychological, and social dimensions of well-being, reflecting a complex interplay between gender-specific anatomy, hormonal influences, and socio-environmental exposures. These conditions encompass a wide spectrum of chronic and acute issues affecting muscles, joints, ligaments, and associated soft tissues, often leading to debilitating pain, reduced mobility, and compromised quality of life(54). The burden of MSDs extends beyond individual suffering to include increased healthcare costs, work absenteeism, and diminished productivity, posing a substantial challenge to both personal and societal health systems. In the global burden of disease rankings, MSDs remain among the top contributors to years lived with disability, surpassing numerous non-communicable diseases that have traditionally dominated women's health research (98).

Historically, age-related degeneration has been perceived as the primary driver of MSD prevalence in women. However, recent evidence suggests a paradigm shift: younger women are now emerging as a vulnerable group due to changing lifestyle trends and occupational demands (100). Young adult women are increasingly reporting posture-related back pain, neck strain, and shoulder difficulties linked to rapidly evolving lifestyle behaviours characterised by academic stress, extended screen exposure, sedentary study routines, and reduced engagement in physical fitness (79). The digitalisation of education and work, coupled with inadequate ergonomic awareness, has further amplified the incidence of musculoskeletal discomfort among students and early-career professionals (102). This shift indicates that

musculoskeletal vulnerability is no longer confined to older populations but is increasingly affecting younger groups during peak physical and developmental stages. Such trends underscore the urgent need for early prevention strategies, ergonomic education, and lifestyle interventions aimed at mitigating the rising burden of MSDs among women in both academic and professional settings (53).

### 1.1 Regional Context: Women's Health in Bahrain

Bahrain, as part of the rapidly modernising Gulf region, presents a unique socio-environmental landscape influencing women's physical health (95). The intersection of rapid urbanisation, economic transformation, and cultural expectations has reshaped daily living patterns, often in ways that inadvertently limit opportunities for physical activity. Traditional gender roles, climatic limitations on outdoor activity, and increased dependence on technology-mediated tasks contribute to significant reductions in daily movement and exercise participation among women (93). High ambient temperatures for much of the year discourage outdoor recreation, while social norms and modesty considerations further restrict participation in mixed-gender physical activities. Despite governmental initiatives promoting sports among Bahraini females, including the establishment of women-only gyms and university-based fitness programs, data show that more than 60% do not meet recommended physical activity guidelines, with the prevalence of sedentary work and education environments continuing to rise (42).

Furthermore, Bahrain ranks among regions with a high prevalence of vitamin D deficiency, overweight and obesity, and ergonomic strain resulting from digital lifestyles — all of which are recognised as major risk modifiers for musculoskeletal disorder (MSD) development (42). Vitamin D deficiency, compounded by limited sunlight exposure due to indoor-oriented lifestyles and traditional clothing, weakens musculoskeletal integrity and predisposes women to chronic pain and fatigue. University students commonly encounter prolonged sitting during lectures, studying, and digital entertainment, while working women often report repetitive strain and biomechanical load from office-based roles (Steyn, 2024). Such occupational and educational demands, combined with limited access to structured physical activity, create a sustained imbalance between physical exertion and recovery. These distinct yet overlapping lifestyle pressures warrant careful examination of MSD determinants across age-specific cohorts within the same sociocultural ecosystem (45). Understanding these contextual influences is critical for designing gender-sensitive health interventions, ergonomic policies, and awareness campaigns tailored to Bahrain's evolving socio-cultural and occupational dynamics.

### 1.2 Performance and Functional Health Implications

Beyond pain and discomfort, musculoskeletal disorders (MSDs) significantly influence women's functional performance — affecting strength, balance, flexibility, and biomechanical efficiency necessary for optimal participation in physical activities, active labour, and sport (7). The musculoskeletal system serves as the foundation for mobility, posture, and endurance; thus, even mild dysfunction can lead to cumulative physical limitations that restrict daily activities and overall quality of life. Reduced musculoskeletal function can hinder academic productivity in younger women and compromise occupational output and caregiving responsibilities in adults (1). In academic settings, students with MSD-related pain often experience decreased concentration, absenteeism, and lower engagement in physical education or extracurricular activities. Among working women, repetitive strain and fatigue can impair task precision, increase the risk of workplace injury, and contribute to long-term occupational disability (22).

Furthermore, MSD-related impairments extend to psychosocial domains, as chronic pain and functional restriction may lead to stress, anxiety, and diminished self-efficacy — reinforcing a cycle of inactivity and further deconditioning (32). These challenges are particularly concerning in societies where women play multiple concurrent roles as professionals, caregivers, and homemakers, requiring sustained physical capability and endurance (142). Therefore, understanding musculoskeletal health is crucial not only from a disease-prevention lens but also from a performance enhancement and healthy living perspective. Integrating ergonomics, preventive exercise, and posture awareness into women's daily routines could serve as a pivotal strategy to preserve functional capacity, promote well-being, and reduce the long-term socioeconomic burden associated with MSDs (113).

### 1.3 Sedentary Behaviour and Musculoskeletal Risk

Prolonged sedentary time — characterised by sitting or low-energy postures — has been identified as an independent health risk, even in individuals who meet exercise recommendations (119). The modern digital lifestyle, dominated by extended screen exposure and remote work or study routines, has intensified daily sedentary behaviour across all age groups, particularly among women balancing academic, occupational, and domestic roles. Mechanistically, sedentary behaviour contributes to muscular imbalance, weakened postural support, decreased spinal stability, and impaired blood circulation — direct precursors of MSDs. Extended static postures also accelerate mechanical loading on the lumbar and cervical spine, leading to chronic tension in the neck, shoulders, and lower back (142).

Studies among women aged 18–45 found that daily sedentary time exceeding 8 hours increases the likelihood of chronic musculoskeletal pain by up to 2.5 times (126). Furthermore, ergonomic inadequacies — such as inappropriate chair height, poor workstation design, and lack of lumbar support — amplify the mechanical strain on musculoskeletal structures. The relationship becomes even more pronounced when ergonomic factors and reduced core strength co-exist. In the Bahraini context, this issue is further compounded by the dominance of office-based occupations, digital education systems, and leisure activities centred around screen use, all of which perpetuate sedentary habits among women (59).

### 1.4 Protective Role of Physical Activity

Conversely, regular physical activity (PA), particularly weight-bearing and musculoskeletal-strengthening exercises, plays a preventive role in maintaining tissue resilience, neuromuscular activation, and joint integrity (112). Engaging in even moderate-intensity activities such as brisk walking, yoga, or resistance training has been shown to enhance spinal alignment, improve circulation, and mitigate inflammation, thereby reducing the risk of MSD onset. Yet, research indicates that women's participation is negatively influenced by self-efficacy, sociocultural constraints, and limited access to female-oriented sports facilities in Bahrain (146). Cultural norms surrounding modesty, limited availability of women-only exercise spaces, and time constraints due to family responsibilities collectively hinder consistent engagement in physical activity.

Moreover, psychological factors — including low confidence, perceived lack of fitness knowledge, and fear of social judgment — further deter participation in exercise programs (131). Understanding motivation and barriers to active lifestyles is therefore essential in identifying behavioural determinants of MSDs 103). Public health interventions that integrate culturally sensitive exercise programs, community-based awareness campaigns, and ergonomic education could

play a transformative role in enhancing women's physical resilience and reducing musculoskeletal risk across the Bahraini population (81).

### 1.5 Knowledge Gap

Despite rising awareness of musculoskeletal disorders (MSDs) in the Middle East, significant research limitations persist that hinder a comprehensive understanding of women's musculoskeletal health (15). Most available evidence remains fragmented, focusing on isolated variables rather than multidimensional interactions among behavioural, biological, and sociocultural determinants (18). Several key research gaps emerged from the literature review, highlighting the need for a more comprehensive understanding of musculoskeletal disorders (MSDs) among women in Middle Eastern contexts.

#### 1.5.1 Lack Of Comparative Studies

First, there is a lack of comparative studies exploring MSD determinants by age within the same cultural setting. Age significantly influences behavioural patterns, hormonal status, and physiological responses to inactivity (134). Without age-stratified evidence, it is difficult to design preventive interventions that address the specific needs of adolescents, young adults, and middle-aged women.

#### 1.5.2 Psychosocial and Cultural Determinants

Second, psychosocial and cultural determinants of women's health behaviours remain underexplored (61). Many existing studies focus primarily on biological risk factors, neglecting the influence of gender norms, family expectations, and societal attitudes that shape women's lifestyle choices. Ignoring these dimensions limits the relevance and effectiveness of MSD prevention and health promotion strategies targeted toward women (104).

#### 1.5.3 Scarcity of Studies Linking MSD Presence

Third, there is a scarcity of research linking MSD presence to functional and performance outcomes in both young and adult women (111). Understanding how musculoskeletal pain and discomfort affect productivity, physical performance, and overall quality of life is crucial for developing holistic frameworks that integrate health, work efficiency, and sport participation (120).

#### 1.5.4 An Absence of Mixed-Methods Evidence

Finally, an absence of mixed-methods evidence combining quantitative measures with lived experiences restricts the depth of understanding regarding women's coping mechanisms and contextual barriers (66). Quantitative data alone cannot capture the nuanced experiences of pain, mobility challenges, or sociocultural constraints. Integrating qualitative insights allows for more contextually grounded interpretations and the development of culturally sensitive intervention models.

### 1.6 Rationale for the Study

Addressing the identified research gaps is essential for advancing a holistic understanding of musculoskeletal disorders (MSDs) among women in culturally specific contexts such as Bahrain (Nasaif et al., 2023). Existing literature has largely examined MSDs through biomedical or occupational lenses, often overlooking how age, behavioral patterns, and sociocultural factors interact to shape women's musculoskeletal health. As women's lifestyles continue to evolve—characterized by increased technological engagement, sedentary occupations, and shifting family roles—understanding the multifactorial nature of MSD risk becomes increasingly important (36).

This study was therefore designed to bridge several critical knowledge gaps. By comparing young and adult Bahraini women, it examines how age-related behavioural and physiological differences influence MSD prevalence and severity (68). It also incorporates psychosocial and cultural variables to capture the contextual realities influencing women's physical activity and sedentary habits (115). Furthermore, by adopting a convergent parallel mixed-methods design, the research integrates quantitative measures with qualitative insights to provide both measurable and experiential perspectives on musculoskeletal health.

Through this approach, the study aims to generate evidence-based, culturally grounded recommendations for MSD prevention, ergonomic awareness, and lifestyle interventions tailored to women's unique needs in the Gulf region. The findings are expected to contribute to a more comprehensive framework for public health policy, occupational health planning, and gender-responsive wellness initiatives.

### 1.7 Purpose of the Study

This study aims to conduct a comparative mixed-methods investigation examining the influence of sedentary behaviour and physical activity on the prevalence, severity, and anatomical distribution of musculoskeletal disorders (MSDs) among young (18–25 years) and adult (30–50 years) Bahraini women. By integrating both quantitative assessments and qualitative narratives, the study seeks to provide a holistic understanding of how lifestyle behaviours, psychosocial factors, and cultural norms collectively shape women's musculoskeletal health across different life stages.

The study additionally explores the functional performance implications of MSDs, including their impact on mobility, strength, and daily activity, as well as behavioural determinants influencing women's engagement in physical activity and sedentary patterns. Through this multidimensional approach, the research aims to generate actionable insights that can guide preventive strategies, health education, and performance enhancement programs tailored to Bahrain's sociocultural context.

### 1.8 Research Objectives

1. To estimate and compare the prevalence, anatomical distribution, and severity of MSDs between young and adult Bahraini women.
2. To assess and contrast sedentary behaviour and physical activity levels across both age groups using validated scientific instruments (e.g., standardised questionnaires or activity monitors).
3. To evaluate the associations between sedentary time, physical activity levels, and MSD characteristics (e.g., pain intensity, functional limitation) across age groups.
4. To determine the impact of MSD-related symptoms on physical performance, daily functioning, and functional independence in both young and adult women.
5. To explore behavioural, psychosocial, and sociocultural factors influencing women's engagement in physical activity and sedentary practices within the Bahraini context
6. To integrate quantitative findings with qualitative insights in order to identify age-specific determinants of musculoskeletal vulnerability and resilience.
7. To propose evidence-based recommendations for preventive interventions, ergonomic adaptations, and performance enhancement strategies targeted at improving women's musculoskeletal health and functional well-being in Bahrain.

### 1.9 Research Questions

Building upon the stated objectives, this study seeks to address the following key research questions that explore the multidimensional relationships between sedentary behaviour, physical activity, and musculoskeletal health among Bahraini women:

***RQ1:*** How do prevalence patterns, anatomical distribution, and severity of musculoskeletal disorders differ between young (18–25 years) and adult (30–50 years) Bahraini women?

***RQ2:*** What are the age-related variations in sedentary behaviour and physical activity profiles, and how do these behavioural trends reflect lifestyle transitions across adulthood?

***RQ3:*** How strongly are MSD symptoms associated with sedentary time and physical activity levels within each age group, and do these relationships differ in magnitude or direction between younger and older participants?

***RQ4:*** What specific functional performance limitations (e.g., mobility, endurance, flexibility) are commonly linked to MSDs across the life span of Bahraini women?

***RQ5:*** What behavioural, psychosocial, and sociocultural determinants influence women's participation in physical activity and their susceptibility to sedentary lifestyles within Bahrain's cultural and environmental context?

***RQ6:*** How can integrating objective quantitative data with subjective qualitative experiences deepen the understanding of MSD determinants and reveal age-specific pathways of vulnerability and resilience?0

Collectively, these questions aim to produce a comprehensive understanding of how biological, behavioural, and sociocultural dimensions interact to shape musculoskeletal health outcomes among Bahraini women.

### 1.10 Research Hypotheses

Grounded in current empirical evidence and theoretical perspectives on sedentary behaviour and musculoskeletal health, the following hypotheses are proposed for empirical testing:

***H1:*** Adult Bahraini women will demonstrate significantly higher prevalence and severity of musculoskeletal disorders than younger women due to cumulative physiological strain and occupational exposure.

***H2:*** Sedentary behaviour will show a positive and statistically significant association with MSD occurrence in both age groups, indicating its role as an independent health risk factor.

***H3:*** Higher levels of physical activity will be inversely associated with MSD prevalence and severity, supporting the protective role of active lifestyles.

***H4*:** Age will moderate the strength of associations among sedentary behaviour, physical activity, and MSD symptoms, with older women expected to exhibit stronger interrelations due to reduced musculoskeletal adaptability.

***H5:*** Functional performance impairments (e.g., reduced strength, mobility, and endurance) will be more pronounced in adult women as a result of cumulative biomechanical stress, prolonged sedentary exposure, and decreased functional reserve.

## Theoretical Framework

This study is guided by an integrated theoretical model that combines three complementary perspectives to holistically examine musculoskeletal health among Bahraini women:

- Biopsychosocial Model of Health, (2020)
- International Classification of Functioning, Disability and Health (ICF), (2001)
- Sedentary Behaviour and Physical Activity Health Model (SBPAHM), (2020)

Together, these frameworks enable a multilevel, mixed-methods interpretation of how biological, psychological, behavioural, and sociocultural factors interact to influence the onset, progression, and consequences of musculoskeletal disorders (MSDs) across different age groups.

### 2.1 Framework Rationale

The integrated framework provides a comprehensive view of how women's musculoskeletal health, performance, and functional outcomes are shaped by interacting domains (86).

| Framework Domain | Example Variables | Relevance to MSDs |
|---|---|---|
| Biological | Age, BMI, bone mineral density (BMD), muscle strength | Determine baseline susceptibility to mechanical overload and degenerative changes |
| Psychological | Fear-avoidance beliefs, motivation, and perceived fatigue | Influence pain persistence, adherence to activity, and coping responses |
| Social / Cultural | Family support, gender norms, and cultural exercise restrictions | Shape behavioural engagement in physical activity and recovery patterns |
| Behavioural / Environmental | Sedentary time, PA levels, ergonomic set-up, climate exposure | Act as modifiable risk factors mediating MSD development and prevention |
| Functional Performance (ICF link) | Sitting tolerance, lifting capacity, work/sport participation | Translate impairments into real-world limitations and reduced quality of life |

**Table 1:** Conceptual Framework Domains and Example Variables Related to Musculoskeletal Disorder (MSD) Risk.

This multidimensional integration captures the interdependence between physical health and social environment, which is particularly salient in Bahrain's gendered sociocultural landscape.

### 2.2 Biopsychosocial Model (BPS)

The Biopsychosocial Model of Health, (2020) conceptualises health and disease as outcomes of dynamic interaction among biological, psychological, and social dimensions (Tam et al., 2024).

In this study, it serves as the overarching interpretive lens to analyse how:

- Biological vulnerability (e.g., age-related tissue decline, low vitamin D, obesity) interacts with (20).
- Psychological states (e.g., motivation, stress, self-efficacy), and (73).
- Social-environmental contexts (e.g., cultural restrictions, family roles) influence MSD prevalence, symptom persistence, and behavioural choices related to activity and rest (72).

This approach allows both quantitative analysis (of measurable physical and behavioural variables) and qualitative exploration (of lived experiences and psychosocial perceptions), making it ideal for the mixed-methods design of this study.

### 2.3 WHO International Classification of Functioning (ICF)

The ICF framework links impairments to functional limitations and participation restrictions (33). Within this research:

- Body Structure and Function → Examines spinal alignment, joint loading, and muscle strength (43).
- Activity → Evaluates sitting tolerance, lifting capacity, and movement efficiency (96).
- Participation → Considers academic performance, work duties, and recreational engagement (148).

By mapping MSD symptoms to functional outcomes, the ICF facilitates analysis of how physical impairments affect women's everyday performance—an aspect rarely addressed in previous GCC research (122).

Sedentary Behaviour and Physical Activity Health Model (SBPAHM)

The Sedentary Behaviour and Physical Activity Health Model (132) extends traditional health models by emphasising that sedentary time is an independent risk factor, distinct from lack of exercise.

It conceptualises health along two behavioural continua:

- Sedentary Behaviour Spectrum: time spent sitting, reclining, or using screens (24).
- **Physical Activity Spectrum:** intensity and frequency of musculoskeletal and aerobic movement (127).

This dual-continuum model helps explain why MSDs may develop even among individuals meeting PA guidelines if sedentary exposure remains excessive—a particularly relevant mechanism in digitally active Bahraini women (125).

### 2.5 Conceptual Integration

By merging the Biopsychosocial Model of Health, (2020), International Classification of Functioning, Disability and Health (ICF), (56), and Sedentary Behaviour and Physical Activity Health Model (SBPAHM), (132) frameworks, this study builds a multilevel analytical structure:

- **Micro-level (biological/biomechanical):** Body composition, joint load, and pain perception (97).
- **Meso-level (psychological/behavioural):** Motivation, sedentary time, PA engagement (39).
- **Macro-level (sociocultural):** Gender norms, access to exercise spaces, ergonomic environment (92).

This integration supports both causal modelling (quantitative phase) and interpretive depth (qualitative phase), allowing exploration of how age moderates these relationships.

### 2.6 Application to the Bahraini Context

This framework is particularly suitable for Bahraini women because it:

- Captures age-specific, multilevel drivers of MSD vulnerability (biological, behavioural, psychosocial).(74).
- Facilitates quantitative + qualitative synergy, aligning with the mixed-methods approach.
- Provides analytical pathways for moderation (e.g., the role of age) and mediation (e.g., motivation, social norms) (144).
- Supports intervention translation — enabling development of performance enhancement and health promotion strategies relevant to local cultural norms.

### 2.7 Conceptual Summary

This integrated conceptual framework, therefore, justifies and guides the current comparative mixed-methods study. By distinguishing young (18–25 years) and adult (30–50 years) Bahraini women, the research will systematically track sedentary behaviour, physical activity levels, MSD prevalence, and performance outcomes within a culturally grounded context (11).

The resulting model aims to generate evidence-based, context-specific preventive strategies that promote musculoskeletal resilience and functional empowerment among women in Bahrain.

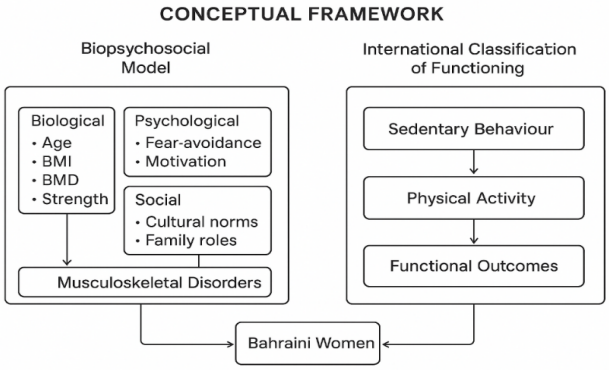


**Figure 1.** Conceptual Framework Illustrating the Biopsychosocial and Behavioural Determinants of Musculoskeletal Disorders Among Bahraini Women

## Literature Review

### 3.1 Conceptualisation of Musculoskeletal Disorders (MSDs)

Musculoskeletal disorders (MSDs) encompass a broad spectrum of acute and chronic conditions affecting muscles, joints, ligaments, bones, tendons, and associated connective tissues (151). These conditions include nonspecific low back pain, cervical strain, patellofemoral pain, tendinopathies, carpal tunnel syndrome, and early degenerative joint changes. MSDs are now recognised as the leading global cause of disability, contributing to reduced productivity, increased healthcare expenditure, absenteeism, and diminished quality of life, particularly among women (151). Their multifactorial ethology reflects the complex interplay of biomechanical loading, hormonal and metabolic influences, psychological stressors, and modifiable lifestyle behaviours (151).

Recent high-impact studies (2022–2025) demonstrate a notable epidemiological shift in the age distribution of MSDs, revealing an alarming rise among younger populations (64). Historically concentrated in middle-aged adults, MSDs are now increasingly observed in university-aged females, largely reflecting sedentary digital lifestyles, poor ergonomic awareness, and inadequate neuromuscular conditioning (75). The symptomatic trajectory of MSD manifestation appears to follow a developmental continuum:

- **Younger females:** Posture-related pain, particularly in the neck, shoulders, and upper back, associated with prolonged screen exposure and suboptimal workstation ergonomics (49).

- **Adult females:** Chronic lower back, hip, and knee discomfort linked to occupational sitting, repetitive strain, weight-bearing asymmetry, and age-related tissue degeneration (130).

Pain chronicity in MSDs is increasingly understood through the lens of central sensitisation, a neurophysiological process in which persistent nociceptive stimulation enhances central nervous system responsiveness, leading to heightened pain perception and prolonged disability (19) Biomechanically, prolonged flexed postures induce cervical extensor fatigue, scapular protraction, and anterior pelvic tilt, resulting in impaired spinal stability and increased loading of posterior spinal elements. Over time, these mechanical adaptations contribute to maladaptive movement patterns and sustained musculoskeletal strain.

From a gendered health perspective, women may experience distinct biomechanical and hormonal susceptibilities (23). Fluctuations in Estrogen levels, differences in muscle composition, and occupational trends involving static work positions can modulate pain thresholds and recovery capacity (71). Additionally, psychosocial stressors, including multitasking demands and caregiving responsibilities, can exacerbate musculoskeletal tension and impede rehabilitation.

The WHO Results Report 2023, (2024) Strategy emphasises early preventive interventions targeting youth populations to address modifiable lifestyle risks before irreversible pathology develops. This emphasis directly aligns with the present study's focus on Bahraini women, highlighting the necessity of preventive ergonomic education, active lifestyle promotion, and functional conditioning to mitigate the onset and progression of MSDs across different age groups.

### 3.2 Age as a Determinant of Musculoskeletal Disorders (MSDs)

Age serves as a critical determinant of musculoskeletal vulnerability, influencing MSD onset and progression through anatomical, hormonal, and behavioural pathways. It not only affects biological tissue integrity but also shapes lifestyle choices, occupational demands, and adaptive responses to pain and physical strain (101).

During early adulthood (18–25 years), women are at a pivotal stage of musculoskeletal development, when bone mass, muscle strength, and postural control are still consolidating. Studies indicate that prolonged sedentary behaviour during late adolescence and early adulthood disrupts peak bone mineralisation and neuromuscular strength, both of which are key protective factors against later musculoskeletal dysfunction (41) A lack of sufficient weight-bearing activity and extended screen-based study habits can impair proprioception, weaken core musculature, and predispose young women to posture-related pain syndromes such as neck and upper back strain.

In contrast, adult women (30–50 years) experience a distinct set of biomechanical and physiological challenges associated with perimenopausal hormonal fluctuations, collagen and muscle deterioration, increased occupational and household physical demands, and the onset of degenerative joint changes (16). The progressive decline in estrogen levels during the perimenopausal period reduces bone mineral density and alters connective tissue elasticity, contributing to joint stiffness and greater injury susceptibility. Chronic musculoskeletal pain becomes markedly more frequent after age 30, with low back and knee pain dominating female morbidity statistics in regional studies (28)

In the Gulf region, additional environmental and lifestyle factors compound age-related vulnerabilities. Vitamin D deficiency, limited sunlight exposure due to cultural clothing norms, and high rates of obesity exacerbate skeletal fragility and musculoskeletal discomfort. Bio-clinical studies in Bahrain report decreased bone mineral density (BMD) among both adolescents and adult females, suggesting early-onset risk accumulation and suboptimal musculoskeletal adaptation (40) These findings underscore that musculoskeletal deterioration may begin far earlier than previously assumed, particularly within populations exposed to low physical activity and high sedentary time.

Therefore, age should not be viewed solely as a biological variable but as a dynamic determinant that integrates physiological change, behavioural adaptation, and psychosocial context Cianconi et al., (30). It influences not only pain sensitisation timelines and recovery potential but also occupational exposure, lifestyle routines, and ergonomic risk. Understanding these age-specific trajectories is essential for developing targeted preventive interventions—from promoting active habits and ergonomic awareness in young women to managing degenerative risk factors and strength maintenance in adults.

### 3.3 Sedentary Behaviour and Musculoskeletal Disorder (MSD) Risk

Sedentary Behaviour Research Network, (2017) is defined as any waking activity expending ≤1.5 METs, (2019) in a sitting or reclining posture. WHO Guidelines on Physical Activity and Sedentary Behaviour, (2020) identify >8 hours per day of sedentary time as a high-risk threshold for multiple health outcomes, including musculoskeletal dysfunction. Recent national surveys report that Bahraini female students and office workers frequently exceed this limit, reflecting a marked cultural and occupational transition toward desk-based and digital lifestyles (93).

#### 3.3.1 Biomechanical Pathways of Sedentary Risk

Prolonged sitting generates sustained mechanical load on the lumbar and cervical spine, leading to disc compression, reduced intervertebral diffusion, and postural muscle fatigue (159). Static loading promotes muscle imbalance—tightness in hip flexors and hamstrings coupled with weakness in the gluteus medius and core stabilisers—resulting in compensatory strain across the kinetic chain (94).

Common consequences include

Static lumbar and cervical postural loading

- Reduced trunk stability and impaired proprioceptive control
- Altered scapular mechanics leading to shoulder and neck pain
- Increased intradiscal pressure and spinal stiffness

Biomechanical research increasingly links sitting-induced hypomobility with circulatory restriction, low-grade inflammation, and delayed muscle recovery, creating a physiological environment conducive to MSD development (46).

#### 3.3.2 Empirical Evidence Linking Sedentary Patterns and MSD Outcomes

Meta-analyses (2021–2024) consistently confirm strong associations between sedentary exposure and musculoskeletal pain across occupational and student populations (89).

| Sedentary Pattern | MSD Outcome | Evidence Strength |
|---|---|---|
| Screen time >6 h/day | Neck and shoulder pain | High |
| Prolonged occupational sitting | Low back pain | High |
| Gaming/social media overuse | Upper limb tendinopathies | Moderate |

**Table 2:** Summary of Sedentary Behaviour Patterns and Associated Musculoskeletal Disorder (MSD) Outcomes.

**Note:** The table summarises key sedentary behaviour types and their corresponding musculoskeletal outcomes as reported in prior research. Evidence strength indicates the consistency and quality of supporting studies linking specific sedentary patterns—such as prolonged screen exposure, occupational sitting, and digital media overuse—to regional MSD symptoms.

Studies from Saudi Arabia, Qatar, and the United Arab Emirates report that over 70% of female workforce participants experience work-related MSD symptoms linked to extended seated tasks and repetitive digital device use (78)

#### 3.3.3 Sedentary Behaviour Trends Among Bahraini Women

In Bahrain, sedentary lifestyles are intensified by sociocultural and environmental conditions that promote seated, indoor activities (6). Contributing factors include:

- Extended social media engagement and digital leisure
- Post-pandemic adoption of e-learning and remote work systems
- Reduced outdoor mobility due to extreme climatic conditions and driving reliance

Recent longitudinal data show that neck pain prevalence among Bahraini university women nearly doubled from 2017 to 2024, a trend attributed to increased digital dependence and static screen postures (118)

Collectively, the evidence identifies sedentary behaviour as a critical independent predictor of MSDs among both young and adult Bahraini women (14). Beyond mere inactivity, sedentary exposure operates through biomechanical, metabolic, and behavioural channels that heighten musculoskeletal vulnerability. Integrating objective measures (e.g., accelerometer-based sedentary time) with subjective postural and ergonomic assessments will be essential for the current study to accurately quantify MSD determinants across age groups (121).

### 3.4 Physical Activity and Its Preventive Role in Musculoskeletal Health

Physical Activity, (2024) plays a multidimensional preventive role in maintaining musculoskeletal integrity by enhancing tissue strength, postural control, metabolic efficiency, and psychological well-being. Unlike passive sedentary patterns, Physical Activity, (2024) induces adaptive remodelling of musculoskeletal tissues that sustain long-term functional resilience.

#### 3.4.1 Physiological Mechanisms of Protection

Physical Activity, (2024) promotes musculoskeletal health through several interconnected mechanisms:

- Strengthening soft tissues → reduces localised mechanical overload on joints and tendons by distributing force more efficiently across muscle groups (77).
- Improving postural balance and neuromuscular coordination → lowers the risk of falls and repetitive strain injuries (156).
- Stimulating osteogenic activity → enhances bone mineral density and slows osteopenia and degenerative changes (161).
- Modulating systemic inflammation and neurochemical stress → decreases pain sensitivity and psychosomatic fatigue (87).

Collectively, these adaptations form the biological basis for MSD prevention, supporting both functional capacity and long-term performance longevity.

#### 3.4.2 Evidence-Based Guidelines and Bahraini Context

According to the The Work of WHO in the Eastern Mediterranean Region, (2024), adults should engage in ≥150 minutes per week of moderate-intensity activity combined with resistance training at least twice weekly. However, only 25–35% of Bahraini women currently meet these thresholds, highlighting a persistent national activity deficit. Cultural norms, climatic barriers, and competing domestic or occupational demands contribute to low adherence(158).

#### 3.4.3 Recent High-Quality Evidence (2022–2025)

Emerging clinical and experimental research reinforces the protective and rehabilitative power of PA:

| Type of Physical Activity | Observed Musculoskeletal Outcome | Effect Magnitude / Evidence |
|---|---|---|
| Resistance training | ↓ Chronic pain severity by 30–40% | Strong (multiple RCTs) |
| Core stabilisation exercise | ↓ Low-back pain recurrence by ~45% | Strong |
| Yoga / Pilates | ↑ Cervical posture, shoulder endurance, and flexibility | Moderate–High |
| Aerobic–strength integrated training | ↓ Overall MSD incidence and improved posture | Consistent evidence |

**Table 3:** Summary of Physical Activity Types and Their Effects on Musculoskeletal Disorder (MSD) Outcomes

**Note:** The table presents evidence from intervention and observational studies linking specific physical activity modalities to musculoskeletal health benefits. Resistance and core stabilisation training demonstrate strong evidence in reducing chronic pain and recurrence, while mind–body exercises such as yoga and Pilates show moderate-to-high evidence for posture and flexibility improvement. Integrated aerobic–strength training consistently reduces overall MSD incidence and enhances postural stability (34).

A 2024 randomised controlled trial in Qatar found that a 12-week performance-oriented strength and agility program among employed women produced significant reductions in neck and low-back symptoms, alongside improvements in occupational productivity and perceived quality of life (4)

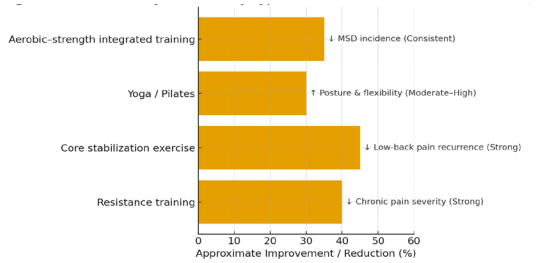


**Figure 2:** Effects of Physical Activity types on Musculoskeletal Disorder (MSD) outcomes

#### 3.4.4 Psychosocial and Behavioural Dimensions

Beyond physiological gains, regular physical activity enhances self-efficacy, body awareness, and emotional well-being, all of which contribute to pain tolerance and consistent exercise adherence (Oh & Aquino, 2024). Conversely, women reporting low motivation, time constraints, or sociocultural restrictions are more likely to maintain sedentary lifestyles, perpetuating MSD vulnerability.

Thus, behavioural reinforcement strategies—including social support, workplace movement breaks, and culturally tailored exercise programs—are key for sustainable participation among Bahraini women (26).

In summary, physical activity is both a preventive and rehabilitative tool for MSD management (25). By improving muscular strength, postural efficiency, and psychosocial resilience, PA mitigates biomechanical and inflammatory pathways underlying musculoskeletal dysfunction. For Bahraini women—particularly those balancing professional and domestic demands—structured, accessible PA programs represent an essential pathway to reduce MSD burden and promote lifelong functional health (17).

### 3.5 Women in Performance and Health Context

Women's musculoskeletal health must be contextualised within the multifaceted performance demands of contemporary life, where they navigate overlapping roles in education, employment, and caregiving (69). The cumulative biomechanical and psychosocial strain generated by these intersecting responsibilities frequently exceeds women's available physiological capacity, predisposing them to overuse injuries, fatigue, and chronic musculoskeletal pain (65). This imbalance has been described as "performance insufficiency syndrome"—a state in which physical preparedness fails to match occupational, domestic, or recreational demands.

#### 3.5.1 Regional Behavioural and Environmental Constraints

Within the Gulf Cooperation Council, (1981) and particularly in Bahrain, women face distinct sociocultural and environmental barriers that limit their engagement in regular physical activity and structured conditioning programs:

- Limited access to female-only sports facilities restricts routine participation (29).
- Social and cultural norms emphasising modesty may discourage outdoor or mixed-gender exercise (60).
- Time scarcity resulting from multitasking—balancing work, study, and family care—reduces opportunities for organised activity (47).
- Extreme climatic conditions for much of the year constrain outdoor training possibilities (62).
- Dependence on vehicle transport further reduces incidental physical activity in daily life (163).
- Together, these constraints promote low habitual movement levels, perpetuating musculoskeletal deconditioning and decreased functional efficiency (51).

#### 3.5.2 Psychosocial Influences on Performance and Health

Recent qualitative and mixed-methods studies across Gulf Cooperation Council, (1981) populations reveal that psychosocial determinants are as influential as physical ones in shaping women's health behaviour (61):

Low self-efficacy and limited confidence in exercise capability predict early dropout from fitness or rehabilitation programs (67)

Body-image concerns and discomfort in public fitness settings inhibit participation, especially among younger women (115).

Social support—from family, peers, or institutional networks—is one of the strongest predictors of sustained physical activity engagement.

Perceived fatigue and role overload among adult women act as barriers to consistency, while younger women cite academic pressure and digital leisure as key contributors to sedentary routines (115)

Such findings underscore that interventions must target not only physical capability but also motivation, confidence, and cultural acceptability.

#### 3.5.3 Why Studying Performance Matters?

Positioning musculoskeletal health within a performance framework expands the relevance of MSD research beyond clinical epidemiology to include functional optimisation and quality-of-life outcomes. A performance-based approach:

- Enhances daily functional efficiency and minimises fatigue in occupational and household roles.
- Improves workplace productivity by maintaining biomechanical readiness for repetitive or static tasks (24).
- Facilitates participation in sport and structured exercise, supporting preventive and rehabilitative goals.
- Reduces long-term healthcare dependence through improved musculoskeletal resilience (160).
- Empowers women's autonomy in managing their own health and fitness behaviours within sociocultural boundaries (140).

Integrating a performance and health dual perspective provides a comprehensive lens for understanding women's musculoskeletal well-being in Bahrain (81). It recognises that physical, psychosocial, and cultural determinants operate simultaneously—shaping not only the risk of MSDs but also the capacity for recovery and sustained activity. Consequently, the current study adopts this dual lens to investigate how sedentary behaviour, physical activity, and performance capability interact across age groups, informing targeted, culturally attuned interventions that enhance both health outcomes and everyday functionality among Bahraini women (84).

## Methodology

### 4.1 Research Design

This study adopts a convergent parallel mixed-methods design, wherein quantitative and qualitative data are collected simultaneously to examine musculoskeletal disorder (MSD) determinants among young and adult Bahraini women. Quantitative data provide measurable trends in sedentary behaviour, physical activity, and MSD prevalence, while qualitative interviews uncover psychosocial, cultural, and behavioural influences. Integration occurs at the interpretation stage, enabling stronger, evidence-driven conclusions related to both performance and health outcomes. This design ensures methodological triangulation, increasing validity and interpretive depth.

### 4.2 Study Population and Sampling Strategy

#### 4.2.1 Study of Population

The study population comprises Bahraini women classified into two developmental stages: young adults (18–25 years) and adults (30–50 years). This classification facilitates the examination of age-related differences in occupational exposure, lifestyle behaviours, and health outcomes. Participants will be recruited from universities, workplaces, and community fitness centres to ensure heterogeneity in occupational and lifestyle contexts.

#### 4.2.2 Sampling Strategy

##### *4.2.2.1 For the Quantitative*

A stratified random sampling technique was used to obtain proportional representation from each age group. Sample size estimation was conducted using G*Power 3.1 software, assuming a medium effect size ($f = 0.25$), a significance level of $\alpha = 0.05$, and a statistical power of 0.80. The minimum required sample per group was calculated as 128 participants. To accommodate potential attrition and ensure sufficient analytical power, the final target sample comprises 300 women, with 150 participants allocated to each group.

Recruitment of young women (18–25 years) was undertaken through universities and sports clubs, whereas adult women (30–50 years) were recruited from workplaces and community centres. This approach allows for comprehensive representation across educational, occupational, and social backgrounds, thereby enhancing the external validity of the study findings.

##### *4.2.2.2 For the Qualitative*

For the qualitative component, a purposive subsample of approximately 20–30 participants was selected to capture a range of musculoskeletal disorder (MSD) experiences, physical activity levels, and sociocultural contexts. This mixed-methods approach aims to provide complementary insights into the psychological and environmental factors influencing women's musculoskeletal health and behaviour.

### 4.3 Inclusion and Exclusion Criteria

#### 4.3.1 Inclusion Criteria

Participants were eligible for inclusion if they were Bahraini women aged either 18–25 years or 30–50 years, representing the two targeted developmental stages of young and adult women. Both sedentary and physically active individuals were included to capture a broad range of physical activity patterns and lifestyle variations (137). Additional inclusion requirements comprised the ability to read and comprehend Arabic or English and the provision of voluntary informed consent to participate in the study.

#### 4.3.2 Exclusion Criteria

Exclusion criteria included the presence of chronic neurological or musculoskeletal disorders, a history of major musculoskeletal surgery within the previous six months, and current pregnancy (82). Individuals with severe cognitive impairment that could interfere with questionnaire completion or interview participation were also excluded. These criteria were applied to ensure that participants were physically and cognitively capable of completing the study assessments without undue burden or confounding health limitations (27).

### 4.4 Data Collection Tools

#### 4.4.1 Quantitative Instruments

The Standardised Nordic Questionnaires for the Analysis of Musculoskeletal Symptoms, (1987) will be used to determine MSD prevalence, severity, and affected anatomical regions over the past 12 months and 7 days. It is widely validated in occupational and epidemiological health studies.

The International Physical Activity Questionnaire: 12-country Reliability and Validity, (58) will assess sedentary duration and intensity levels of physical activity (walking, moderate, vigorous). Activity scores will be categorised into low, moderate, and high based on MET-minutes per week.

Pain intensity was recorded using a Visual Analogue Scale (VAS), (149) ranging from 0 (no pain) to 10 (severe pain). Additionally, functional performance tests—including posture, flexibility, and strength assessments—will be conducted to examine ergonomic and physical outcomes.

#### 4.4.2 Qualitative Instrument

Semi-structured interviews explored behavioural routines influencing sedentary lifestyle, perceived barriers and motivators for physical activity, social and cultural norms shaping movement behaviours, and the impact of pain on performance and daily functioning (63). All interviews were conducted in Arabic or English, audio-recorded, and transcribed verbatim for thematic analysis.

### 4.5 Variables and Operational Definitions

The study examined four primary variables: sedentary behaviour, physical activity, age group, and musculoskeletal disorder (MSD) status. Sedentary behaviour and physical activity were treated as independent variables, age group served as a moderating variable, and MSD status was designated as the dependent variable (141).

#### 4.5.1 Independent variables

Sedentary behaviour was operationally defined as the total number of hours spent sitting or engaging in screen-based activities per day (52). Physical activity was measured as the weekly metabolic equivalent (MET) minutes score and classified into three categories: low, moderate, and high activity levels. Both variables were assessed using the International Physical Activity Questionnaire: 12-country Reliability and Validity, (58), a validated instrument widely used to quantify habitual activity and sedentary time in population studies.

#### 4.5.2 Moderating variable

The moderating variable, age group, was defined as a categorical factor distinguishing young women (18–25 years) from adult women (30–50 years). Classification was based on participants' self-reported age recorded in the demographic form.

#### 4.5.3 Dependent variable

The dependent variable, MSD status, was measured using the Standardised Nordic Questionnaires for the Analysis of Musculoskeletal Symptoms," (1987) which assesses the presence and intensity of musculoskeletal pain across nine body regions. Pain intensity was rated on a 0–10 numeric scale, with 0 indicating no pain, 1–3 representing mild pain, 4–6 denoting moderate pain, and 7–10 reflecting severe pain.

#### 4.5.4 Summary of operational definitions

This operational framework ensured consistent measurement of all study variables and enabled the systematic analysis of relationships among physical activity, sedentary behaviour, age group, and MSD outcomes within the Bahraini women population (81).

### 4.6 Data Analysis Plan

#### 4.6.1 Quantitative Analysis

Data will be analysed using SPSS, (136) and R, (128) software. Descriptive statistics will summarise demographic and behavioural characteristics.

Independent t-tests and Mann–Whitney U tests will compare group differences in MSD prevalence and activity levels.

One-way (13) will assess differences by severity classification.

Pearson or Spearman correlations will explore relationships between sedentary time, physical activity, and pain intensity (107).

Multiple regression analyses will identify predictors of MSD occurrence, and moderation analysis will test whether age moderates the sedentary–MSD relationship (123).

All assumptions (normality, homogeneity, linearity) will be verified prior to final model selection.

#### 4.6.2 Qualitative Analysis

Interview transcripts will be analysed using reflexive thematic analysis guided by the Biopsychosocial Model of Health, (21). The process includes familiarisation, coding, theme generation, peer debriefing, and member checking for validation. Themes will be synthesised to highlight psychosocial and cultural dimensions influencing MSD risk and activity behaviour. Analysis will be supported by NVivo (Version 12), (2020) or MAXQDA, (83)software.

#### 4.6.3 Mixed-methods integration

##### *4.6.3.1 Integration approach*

A mixed-methods triangulation design will be employed to integrate the quantitative and qualitative datasets. A triangulation matrix will be used to systematically merge findings from both strands, enabling the identification of areas of convergence (agreement), complementarity (mutual enrichment), and divergence (discrepancies) (Meydan & Akkaş, 2024). This integrative process enhances the validity and depth of interpretation by linking statistical trends with contextualised participant narratives.

##### *4.6.3.2 Quantitative–qualitative linkage*

Quantitative results from the survey data will be aligned with emergent qualitative themes derived from interviews. For instance, higher sedentary time reported among adult women in the quantitative analysis aligns with qualitative findings emphasising workload and family constraints as key contributors to inactivity (Yu et al., 2025). Conversely, the greater prevalence of neck and back pain reported by younger women corresponds with qualitative themes highlighting prolonged screen exposure and poor posture associated with academic and technological engagement.

##### *4.6.3.2* Integrated interpretation

The integrated analysis suggests that age moderates the influence of sociocultural and environmental factors on sedentary behaviour and musculoskeletal outcomes(Dzakpasu et al., 2021). Among adult women, sedentary patterns appear to be shaped primarily by role-related demands and limited leisure opportunities, whereas among younger women, technology-driven habits contribute to posture-related pain and inactivity. The joint display of these findings provides a comprehensive interpretation of how behavioural, cultural, and ergonomic factors interact across age groups in the Bahraini female population (Al Hammadi, 2023).

### 4.7 Ethical Considerations

Ethical approval was obtained from the Institutional Review Board of European Institute of Management and Technology, Switzerland (EIMT/2024/25) and consent was secured from all participants prior to data collection. Confidentiality was ensured by assigning anonymous codes and securing data in password-protected systems. Participation was voluntary, with the right to withdraw at any point without consequence. Female research assistants conducted data collection to maintain participant comfort and privacy.

### 4.8 Reliability, Validity, and Trustworthiness

Reliability and validity were maintained through several strategies. The Standardised Nordic Questionnaires for the Analysis of Musculoskeletal Symptoms, (1987) and International Physical Activity Questionnaire, (58) are internationally standardised and have demonstrated strong psychometric (88) reliability (Cronbach's $\alpha \geq 0.70$). A pilot test with 20 participants assessed clarity, translation accuracy, and timing. Forward–backward translation ensured linguistic equivalence in Arabic.

For qualitative data, credibility was enhanced through triangulation, member checking, and audit trails, while confirmability was supported by reflexive journaling. Stratified sampling enhances representativeness, and peer review of analytical coding supports dependability and transparency (3).

## Result

### 5.1 Participant Demographics

A total of 300 Bahraini women participated in the study, including 150 young women (18–25 years) and 150 adult women (30–50 years). The sample showed a balanced distribution across both developmental stages. Table 4 presents the demographic characteristics for each age group.

| Variable | Young (n = 150) | Adult (n = 150) | p-value |
|---|---|---|---|
| Age (years), Mean ± SD | 21.4 ± 1.8 | 38.2 ± 5.3 | < 0.001 |
| BMI (kg/m²), Mean ± SD | 23.6 ± 3.4 | 28.1 ± 4.7 | < 0.001 |
| Working/Employed (%) | 28% | 82% | < 0.001 |
| >6 hrs/day Sitting (%) | 56% | 74% | 0.003 |

**Table 4:** Participant Demographics (N = 300)

Adult women demonstrated significantly higher BMI values and longer daily sitting durations compared to younger participants ($p < 0.01$), suggesting greater sedentary exposure and potential vulnerability to musculoskeletal strain.

### 5.2 Prevalence of Musculoskeletal Disorders (MSDs) by Age Group

The overall 12-month prevalence of musculoskeletal disorder (MSD) symptoms across anybody regions was 62.7 %, indicating a high burden of musculoskeletal complaints among Bahraini women. The lower back and neck were the most commonly affected anatomical regions in both age groups (12).

| Anatomical Region | Young (%) | Adult (%) | $\chi^2$ | p-value |
|---|---|---|---|---|
| Neck | 46.7 | 38.0 | 2.25 | 0.13 |
| Shoulders | 33.3 | 41.3 | 2.17 | 0.14 |
| Lower Back | 52.0 | 57.3 | 0.82 | 0.36 |
| Knees | 19.3 | 38.0 | 12.1 | 0.001 * |
| Wrist/Hand | 37.3 | 22.0 | 8.5 | 0.004 * |

**Table 5.** MSD Distribution by Age Group

*Significant at $p < 0.05$*

Adult women reported significantly higher knee pain ($p = 0.001$),

consistent with greater BMI and occupational workload, while younger women experienced more wrist and hand pain ($p = 0.004$), most likely due to extended use of smartphones, laptops, and other digital devices. These findings suggest distinct age-specific MSD risk profiles, highlighting the need for tailored ergonomic and activity-based interventions.

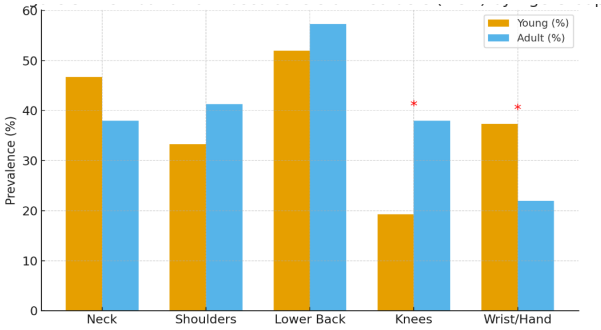


**Figure 3.** Distribution of Musculoskeletal Disorder (MSD) by Age Group

### 5.3 Activity Patterns and Sedentary Behaviour

According to the International Physical Activity Questionnaire, (58) scoring, notable differences were observed between the two age groups in both sedentary time and physical activity levels.

| Measure | Young (18–25 years) | Adult (30–50 years) | t / U | *p*-value | Effect size (d) |
|---|---|---|---|---|---|
| Sedentary time (hours/day) | 6.8 ± 1.9 | 8.3 ± 2.1 | −6.5 | < 0.001* | 0.78 |
| MET-min/week (Moderate–Vigorous PA) | 1280 ± 540 | 960 ± 510 | 4.0 | < 0.001* | 0.56 |

**Table 6:** Group differences in sedentary behavior and physical activity between young and adult women

*Significant at $p < 0.05$

Adult women exhibited significantly higher sedentary time, averaging over 8 hours per day, consistent with greater work-related sitting demands (31). In contrast, younger women demonstrated higher physical activity levels, accumulating more moderate-to-vigorous MET-minutes per week, likely due to increased participation in campus-based and social movement activities.

These findings emphasise a clear behavioural divergence between the groups: while young women may face screen-based risks, adult women experience risks driven by occupational inactivity. Together, these patterns provide important context for understanding age-specific pathways to MSD development identified in this study.

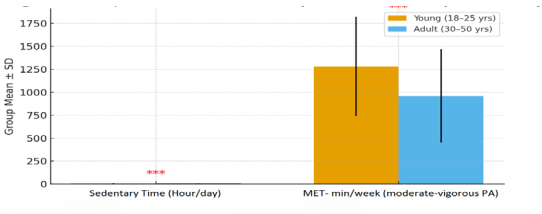


**Figure 4.** Group differences in Sedentary behaviour and physical activity.

### 5.4 Hypothesis testing results

Multiple regression and moderation analyses were conducted to examine the hypothesised relationships between sedentary behaviour, physical activity, and musculoskeletal disorder (MSD) severity, as well as the moderating effect of age group (162).

#### 5.4.1 Regression outcomes

| Hypothesis | Relationship Tested | β | *p*-value | $R^2$ | Outcome |
|---|---|---|---|---|---|
| H1 | Sedentary behaviour → MSD severity | 0.41 | < 0.001* | 0.21 | Supported |
| H2 | Physical activity → MSD severity | −0.29 | 0.002* | — | Supported |
| H3 | Sedentary behaviour × Age group → MSD severity | 0.17 | 0.03* | — | Supported |

**Table 7:** Summary of hypothesis testing results.

**Note:** All models were significant at $p < 0.05$. β = standardized regression coefficient; $R^2$ = explained variance.

The results indicate a significant positive association between sedentary behaviour and MSD severity ($\beta = 0.41$, $p < 0.001$), accounting for 21% of the variance in MSD outcomes. Conversely, higher levels of physical activity predicted lower MSD severity ($\beta = -0.29$, $p = 0.002$), supporting the protective role of physical activity. The interaction between sedentary behaviour and age group was also significant ($\beta = 0.17$, $p = 0.03$), suggesting that the detrimental effect of sedentary time on MSD severity was more pronounced among adult women compared with younger participants.

Overall, sedentary behaviour emerged as a primary risk factor, physical activity served as a protective determinant, and age group acted as a moderating variable amplifying the relationship between inactivity and MSD outcomes (103).

| | Relationship Tested | β | *p*-value | $R^2$ |
|---|---|---|---|---|
| | Sedentary behaviour and MSD severity | 0.41 | <0.001 | 0.21 |
| H2 | Physical activity and MSD severity | -0.29 | 0.002 | |
| H3 | Age group: interaction anod age group | 0.17 | 0.03 | |

Note: All models were significant at $p < 0.05$. $\beta$ = standardized regression, $R^2$ explanieel variance.

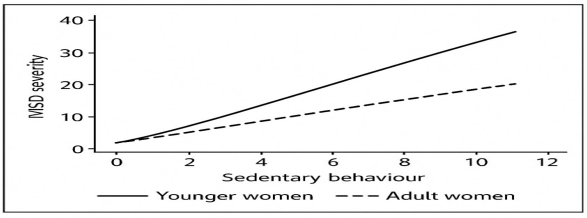


**Figure 5:** Regression outcomes and moderating role of age group in the relationship between sedentary behaviour, physical activity, and musculoskeletal disorder (MSD) severity among Bahraini women.

### 5.5 Qualitative Findings: Thematic Analysis

The qualitative phase explored participants lived experiences related to sedentary behaviour, physical activity, and musculoskeletal health.

Thematic analysis yielded four key themes that contextualise the quantitative findings and illuminate the sociocultural and behavioural factors influencing women's musculoskeletal well-being (114).

#### 5.5.1 Sedentary lifestyle is the norm

Participants consistently described sitting as an unavoidable part of their daily routines, shaped by academic, professional, and domestic obligations. Both young and adult women reported extended hours of sitting associated with computer-based work, study, or household management (76). This normalisation of inactivity reflects a broader cultural acceptance of sedentary patterns as a functional necessity rather than a health concern.

"My whole job is on a computer — I barely stand all day." (Adult)

#### 5.5.2 Social and cultural constraints

Social norms and cultural expectations were identified as major barriers to engaging in regular physical activity (70). Gendered expectations surrounding modesty, limited access to female-only facilities, and safety concerns when exercising outdoors collectively restricted women's opportunities for movement. These constraints were particularly evident among younger participants.

"I want to walk outside, but it's not comfortable alone." (Young)

#### 5.5.3 Pain is ignored until severe

Many participants described a tendency to normalise musculoskeletal discomfort and delay seeking medical or therapeutic assistance until pain became debilitating. Pain was often viewed as a routine aspect of daily life, especially among adult women managing work and family responsibilities (153). This cultural acceptance of pain contributes to the chronicity of musculoskeletal symptoms.

"Pain is part of daily life; we just continue." (Adult)

Limited awareness of protective exercise

A lack of knowledge regarding preventive or corrective exercise emerged as a recurring theme (83). Few participants were familiar with posture-improving or mobility-enhancing activities that could mitigate musculoskeletal strain. This knowledge gap reflects a need for greater health education and community-based awareness initiatives.

"I don't know what exercises prevent back pain." (Young)

Collectively, these themes reveal that sedentary lifestyles are deeply embedded in daily routines, reinforced by sociocultural constraints and limited health literacy (109). The findings underscore the importance of targeted interventions that promote movement, ergonomic awareness, and culturally sensitive exercise education among Bahraini women.

| Theme | Description | Illustrative Quote |
|---|---|---|
| Sedentary lifestyle is the norm | Sitting is perceived as an unavoidable part of daily life, reinforced by academic, professional, and household responsibilities. | "My whole job is on a computer — I barely stand all day." (Adult) |
| Social and cultural constraints | Gender norms, modesty expectations, and safety concerns restrict women's opportunities for outdoor exercise and public participation. | "I want to walk outside, but it's not comfortable alone." (Young) |
| Pain is ignored until severe. | Musculoskeletal discomfort is often normalised, and help is sought only when pain interferes with essential daily functions. | "Pain is part of daily life — we just continue." (Adult) |
| Limited awareness of protective exercise | Knowledge regarding posture correction, stretching, and mobility exercises is limited among participants. | "I don't know what exercises prevent back pain." (Young) |

**Table 8:** Summary of qualitative themes, descriptions, and illustrative quotes.

The qualitative analysis provided rich contextual insight that complemented the quantitative results, elucidating how behavioural, sociocultural, and perceptual factors shape sedentary patterns and musculoskeletal health among Bahraini women (10).

The theme "Sedentary lifestyle as the norm" reinforces the quantitative evidence showing high sedentary time, particularly among adult women (80). Participants described sitting as an inevitable consequence of work and domestic responsibilities, suggesting that occupational structure and household expectations perpetuate inactivity.

The theme "Social and cultural constraints" helps explain the limited engagement in moderate–vigorous physical activity observed in the quantitative data. Cultural norms regarding modesty and limited access to women-friendly environments create structural barriers to exercise (135). These constraints reduce opportunities for active coping strategies that could mitigate musculoskeletal discomfort.

The theme "Pain ignored until severe" illustrates a behavioural tendency toward normalisation of physical strain. This attitude may partially account for the delayed reporting or management of musculoskeletal disorders, thereby intensifying symptom severity. It aligns with the finding that sedentary behaviour was positively associated with MSD severity (162).

The theme "Limited awareness of protective exercise" highlights a gap in knowledge regarding preventive measures, such as posture correction and ergonomic awareness. This lack of health literacy diminishes women's ability to adopt compensatory activities that could reduce MSD risk (104).

Together, these themes demonstrate a multidimensional interplay of behavioural, cultural, and educational factors that reinforce sedentary lifestyles and hinder proactive health behaviours. When integrated with quantitative findings, the results suggest that interventions should not only target behavioural modification but also address cultural accessibility, ergonomic education, and early pain recognition to effectively reduce MSD risk among women in similar sociocultural contexts (2).

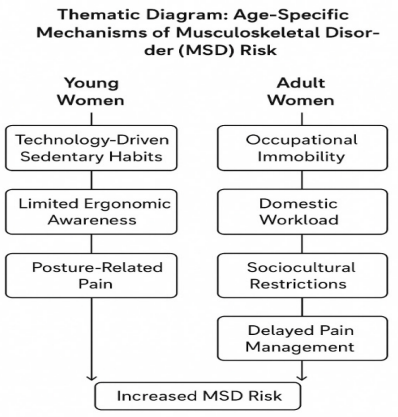


Figure 5. Thematic diagram: Age-specific mechanisms of musculoskeletal disorder (MSD) risk

**Figure 6.** Thematic Diagram: Age-Specific Mechanisms of Musculoskeletal Disorder (MSD) Risk Among Bahraini Women

**Note:** The diagram illustrates distinct behavioural and sociocultural pathways contributing to MSD risk across age groups. Among young women, technology-driven sedentary habits and limited ergonomic awareness led to posture-related pain. Among adult women, occupational immobility, domestic workload, sociocultural restrictions, and delayed pain management collectively heighten MSD vulnerability (110).

# Discussion

This study examined the relationships between sedentary behaviour, physical activity, and musculoskeletal disorder (MSD) severity among Bahraini women across two age groups—young adults (18–25 years) and adults (30–50 years)—using a mixed-methods approach. The quantitative findings revealed that sedentary behaviour significantly increased MSD severity, while higher physical activity levels were associated with lower symptom intensity (9). Age further moderated this relationship, indicating that adults experienced stronger negative effects of sedentary time compared with younger participants. Qualitative data supported and expanded these findings, showing that social, cultural, and behavioural factors collectively shape women's daily movement patterns and pain experiences.

### 6.1 Sedentary behaviour as a primary risk factor

The finding that sedentary behaviour positively predicted MSD severity aligns with existing literature linking prolonged sitting with musculoskeletal pain, particularly in the neck, lower back, and shoulders. Previous studies in similar populations (5) have demonstrated that continuous sedentary exposure reduces spinal flexibility and muscular endurance, leading to cumulative strain. In the present study, sedentary behaviour accounted for approximately one-fifth of the variance in MSD severity, suggesting that inactivity remains a dominant risk factor among women with modern occupational and household demands (105). Qualitative accounts reinforced this interpretation, as participants described sitting for extended hours as a "normal" and often unavoidable part of their work or home routine.

### 6.2 The Protective Role of Physical Activity

The inverse association between physical activity and MSD severity underscores the importance of movement in mitigating musculoskeletal strain (162). Participants with higher weekly MET-min scores reported fewer or less intense MSD symptoms, consistent with evidence that regular moderate-to-vigorous physical activity enhances musculoskeletal resilience and reduces pain perception. However, despite its protective effect, overall activity levels in both groups were below international recommendations, suggesting that even limited increases in activity could yield significant health benefits (44). The qualitative theme "Limited awareness of protective exercise" highlights a crucial barrier—knowledge gaps regarding posture correction, ergonomic habits, and muscle-strengthening routines—underscoring the need for targeted educational interventions.

### 6.3 Age as a Moderating Factor

The moderating effect of age revealed that sedentary time exerted a stronger influence on MSD severity among adult women (35). This finding may be attributed to cumulative exposure to static postures, hormonal and physiological changes, and increased domestic and occupational workloads. Qualitative insights provided further depth: adult participants described being confined to seated roles and feeling socially constrained in their ability to engage in recreational movement. In contrast, younger women's sedentary habits were primarily technology-driven, with posture-related pain emerging from screen use rather than occupational immobility. These age-specific mechanisms, visualised in Figure 4, demonstrate that MSD risk is shaped not only by biological factors but also by evolving lifestyle and sociocultural conditions across the life span (46).

### 6.4 Sociocultural and Behavioural Influences

Cultural and social expectations significantly contributed to the persistence of sedentary patterns. The theme "Social and cultural constraints" captured the influence of modesty norms, limited availability of women-only fitness spaces, and concerns regarding safety in public exercise environments (50). These barriers reduce women's ability to engage in physical activity despite awareness of its benefits. The cultural tendency to "ignore pain until severe" further compounds risk, delaying diagnosis and treatment and contributing to chronicity. Collectively, these findings highlight the interplay of personal behaviour, cultural environment, and gendered social roles in shaping MSD vulnerability.

### 6.5 Integration of Quantitative and Qualitative Findings

The convergence of both data strands supports a multidimensional understanding of MSD risk. Quantitative data identified sedentary behaviour as a key determinant, moderated by age, while qualitative insights contextualised why these patterns persist. Together, they indicate that interventions must go beyond individual behaviour change to address systemic and cultural barriers. Promoting ergonomic awareness, workplace mobility programs, and culturally tailored exercise initiatives may help reduce sedentary exposure and improve musculoskeletal health outcomes among Bahraini women (81).

### 6.6 Implications for Practice and Policy

From a public health perspective, the findings call for integrative prevention strategies targeting both behavioural modification and environmental support. Universities and workplaces should implement ergonomics training, standing breaks, and accessible physical activity facilities. Community-level initiatives should prioritise safe, culturally appropriate exercise spaces for women, along with public campaigns promoting early recognition of musculoskeletal symptoms (48). Health educators should emphasise the role of posture, movement diversity, and self-care to counter the normalisation of pain.

### 6.7 Limitations and Future Directions

While the study provides valuable insights, several limitations should be acknowledged. The cross-sectional nature of the quantitative data restricts causal inference, and self-reported measures may be subject to recall bias. The qualitative sample, though diverse, was limited to

urban participants, which may not fully represent rural or lower-income populations. Future research should adopt longitudinal or interventional designs to evaluate causal pathways and the effectiveness of culturally adapted physical activity interventions (38).

This study demonstrates that sedentary behaviour is a major contributor to musculoskeletal disorder severity among Bahraini women, with age and sociocultural context shaping the magnitude of risk. Physical activity offers a protective buffer, yet is constrained by environmental and cultural factors (8). Integrating ergonomic education, workplace mobility initiatives, and culturally sensitive exercise programs can reduce sedentary exposure and enhance women's musculoskeletal health and overall quality of life.

## Conclusion

This study provides empirical evidence that sedentary behaviour is a significant determinant of musculoskeletal disorder (MSD) severity among Bahraini women, with age acting as a critical moderating factor (11). Quantitative findings revealed that prolonged sitting and low physical activity levels increase the likelihood and intensity of MSD symptoms, while qualitative insights highlighted sociocultural norms, occupational demands, and limited health literacy as underlying contributors.

Collectively, the results emphasise that musculoskeletal health is influenced by a combination of behavioural, cultural, and environmental determinants. Young women are particularly affected by technology-related sedentary habits, whereas adult women face compounding risks due to occupational immobility and domestic responsibilities. These age-specific pathways necessitate tailored health promotion strategies (152).

## Recommendations

### 8.1 Workplace and Institutional Interventions

Introduce structured movement breaks, ergonomic workstation design, and awareness programs in universities and offices to reduce sitting time and encourage mobility (116).

### 8.2 Culturally Adapted Physical Activity Programs

Develop women-only fitness sessions and community-based initiatives that align with local cultural values and provide safe, accessible spaces for exercise (129).

### 8.3 Health Education and Awareness Campaigns

Disseminate educational materials on posture correction, early symptom recognition, and simple daily exercises to prevent chronic MSD progression (129).

### 8.4 Policy-Level Support

Encourage national health policies that integrate physical activity promotion into women's health agendas, including funding for ergonomic training and workplace wellness programs.

## Future Research Directions

Further longitudinal and interventional studies are needed to establish causal relationships and assess the long-term impact of sedentary behaviour modification on MSD outcomes. Future research should also explore the intersection of psychosocial stress, digital media use, and gender norms to develop more comprehensive, context-sensitive health frameworks for women in Middle Eastern societies (150).

By integrating behavioural science with sociocultural understanding, this study underscores the need for multilevel strategies—spanning individual, occupational, and societal domains—to effectively reduce sedentary behaviour and enhance musculoskeletal health (150) among women. Promoting active, ergonomically informed, and culturally inclusive lifestyles will not only mitigate MSD risk but also foster overall well-being and productivity in the female population of Bahrain (81).

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