



Correlation Between Prolonged Physical Activity and Musculoskeletal Injuries Among International Hajj Pilgrims: A Preventive Health Study

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Abstract

Introduction: The largest mass gathering in the world is the Hajj pilgrimage which necessitates the pilgrims to be involved in intensive and prolonged physical activity (PPA), and walking estimated distances of 5 to 15 miles in several days. This vigorous activity exposes unconditioned tissues to considerable biomechanical load, and as a result, musculoskeletal pain (MSP) and acute injuries have high levels of prevalence all over the world, and present a significant challenge to the Saudi health system of Makkah.

Research Objective: The purpose of this study is to investigate the frequency and severity of musculoskeletal injuries (e.g., joint/muscle pain, back strain, blisters, and sprains) that occur among international Hajj pilgrims during prolonged walking and standing during the rituals. Study outcomes will include either the validated musculoskeletal injury questionnaire together with severity scores indicatively graded from self-reported pain scales (0-10).

Research Methods: This is a cross-sectional study that was carried out among a group of international adult pilgrims at Makkah in Saudi Arabia using questionnaires. The statistical analysis involved descriptive measures of prevalence, correlational analysis to evaluate the relationship between PPA and the injury severity and Chi-Square tests to evaluate whether there is significant categorical relationship between demographics and all the outcomes measured.

Conclusion: This observation is an indicator that the risk and prevention behavior patterns are very homogenous among these large demographic groups. The reported excessive strain implies a joint policy action in terms of compulsory physical conditioning sessions before Hajj and in-field measures, including the maximization of the rest throughout the pilgrimage and the obligatory use of supportive footwear, to minimize the trauma load in Saudi hospitals and guarantee a more safe pilgrimage.

Keywords: Hajj Pilgrimage, Musculoskeletal Injuries (MSKI), Prolonged Physical Activity, Preventive Health, Risk Factors, Lower Extremity Pain.

Introduction

Hajj pilgrimage is the most huge sustained mass meeting in the world with more than two million foreign pilgrims being drawn to Makkah, Saudi Arabia every year. It is a one-of-a-kind event, and a unique one at that, in terms of both scale and the physical intensity of rituals, which is inherent in this event. The physical topography of Hajj, which is characterized by high human population, prolonged periods of time, exposure to environmental degradation factors such as extreme heat, and difficult walking grounds, poses unrelenting and daunting challenges to human health and healthcare provision in the Kingdom of Saudi Arabia (KSA). This population is a multifaceted epidemiological problem due to which the KSA healthcare system must effectively address not only the problems of infectious disease control and management of cardiovascular incidents but also traumas and acute injuries. [1, 2, 5] In this framework, musculoskeletal health appears to be one of the most widespread and at the same time under-researched burdens that heavily affect the success and safety of the pilgrims performing the necessary religious tasks.

MSKI Pathogenesis

The most important/implicit rituals of Hajj require the extreme and prolonged physical activity (PPA) that requires long standing and wide ambulation in between the sacred Makkah, Mina, Arafat and Muzdalifah. This endeavor is way beyond the normal levels of physical activity of most participants, and usually involves walking distances estimated to be 5-15 miles in a number of days. [7, 11, 4] The rituals like the Tawaf seven circuits around the Kaaba and Sa'i 7 trips between Safa and Marwah require prolonged effort, which is mostly carried out on rigid and imprecious surfaces under severe congestion and heat. [8] The spectrum of Musculoskeletal Injuries (MSKI) caused by these demands involves generalized musculoskeletal pain (MSP), muscular-tendon injuries (e.g., spasms and tears), bony injuries (e.g., fractures), joint injuries (e.g. prolapse and severe pain), and ligamentous tear. The PPA that comes with Hajj is postulated to have two main, inter-related injury mechanisms. [3, 11]

The former is Cumulative Overuse Injury, which causes musculoskeletal pains and strains because of chronic repetitive and high loads on unconditioned tissues. The second is the Acute Traumatic Injury which includes falls and subsequent fractures, which often occurs because of fatigue at work, and worsens under the influence of environmental factors. The fact that fatigue was identified as the leading mechanism (55.4) and the number of bony injuries is also significant (26.1) supports the idea that sustained physical activity causes physiological exhaustion, thus impairing balance and stability, and pilgrims are at the highest risk of acute trauma. The prevalence rate of overall MSP in pilgrims is found to be very high, according to cross-sectional studies, the overall rate is 80.46. [15, 7, 2]

This is much higher than the prevalence rate in the majority of the general populations and it is an indicator that there is a distinct and substantial public health burden that needs urgent intervention at the KSA Ministry of Health. Moreover, MSKIs have become a significant burden to society, and they cause high healthcare expenses, diminished physical functioning, disability and low quality of life of the pilgrims affected, and they can no longer serve their religious needs in the best way possible. [6] The necessity to develop specific prevention is defined by the fact that international (non-Saudi) pilgrims have a much higher rate of MSK injuries (85.1%) in comparison to their Saudi colleagues (63%). [9, 13]

This inconsistency implies the existence of a good gap between pre-Hajj preparedness and training that is offered to attendees of the world. One of the commonest health problems that are reported during Hajj are musculoskeletal injuries. Such injuries include simple sprains and strains, and serious ones that include fractures, tears in the ligaments, and long-term joint pains. [12] All of this coupled with lengthy work, congestion, high temperatures, and insufficient preparation make it very likely to develop musculoskeletal issues. The burden of musculoskeletal injuries is especially high among international pilgrims, who usually cover a long distance with them and may not have experience with such severe physical activity in the past. [7, 5] Musculoskeletal complaints are also identified as a major cause of medical consultations in Saudi Arabia during pilgrimage season as is evident in hospital records. Regardless of the magnitude of the issue, the literature addressing the specific relationship between long-term physical activity and musculoskeletal injuries among the international pilgrims is scarce. [13]

The majority of the current literature is focused on infectious diseases or overall public health issues, which has created a gap in prevention of non-communicable injuries of activities. It is important to fill this gap because musculoskeletal injuries are causing spiritual undermining of pilgrims and have also become a heavy burden on Saudi healthcare systems. This research will examine the connection between long-term physical activity and musculoskeletal injuries among the international Hajj pilgrims in Saudi hospitals. Through the identification of risk factors and the correlation of activity patterns with the levels of injury in the future, the study aims to inform preventive health interventions of the ability to increase the safety of pilgrims and decrease the load on hospitals subsequent to Hajj seasons.

Review of Literature

Hajj is another largest mass phenomenon in the world since more than two million pilgrims (different ages and health conditions) visit the holy locations within Makkah and Madinah annually. The ritualistic activities, Tawaf (circum ambulation), Sa'i (walking between Safa and Marwah), Standing at Arafat, spending of nights at Muzdalifah and Mina and stoning at Jamarat require constant locomotion, long standing and repetitive movements of the lower limbs across days. The unique interplay between environmental, logistical, and behavioral variables that differentiate Hajj and physical activity environment and determine the risk of injury has been repeatedly mentioned in the literature on the foundational Hajj health. [1, 2, 3, 4].

Musculoskeletal injuries in Hajj

Hajj seasons re-experience complaints of musculoskeletal (MSK) problems: overuse syndromes (plantar fasciitis, Achilles tendinopathy, patellofemoral pain), soft-tissue (sprains, strains), and traumatic (falls, fractured etc.) trauma. Hospital-based as well as clinic-based descriptive studies, weight-bearing repetition on hard surfaces, on slopes and stairwells along ritual corridors, all point to lower-extremity engagement. Increased rates of MSK presentations and functional limitations are associated with old age, female sex in a number of studies, pre-existing osteoarthritis, obesity, and diabetes. [5, 9].

PPA (Prolonged physical Activity)

The cumulative microtrauma of tendons, ligaments and cartilages of the joints caused by persistent movement without sufficient rest, are the causes associated with tendinopathy, sprains and exacerbation of degenerative arthritis. The fatigue reduces proprioception and neuromotor control that leads to increased missteps, inversion trauma and falls; crowding also contributes to sudden acceleration and deceleration, sudden shear, torsion and compressive forces. Heat and dehydration will undermine muscle endurance, and cramps will become more likely, whereas the neuromuscular impairment can be triggered by the presence of electrolyte. [2,5,8,10, 12].

Environmental and Related Risk Factors

Thermophysiological stress of hot season leads to the decrease in exercise, acceleration of fatigue, which worsens the quality of movement and adds weight to the joints that are susceptible to stress. Handling high density crowding, stride length is reduced and abrupt deceleration then follows multiplying the ankle and knee shear loads; infrastructure gradients and hard surfaces increase eccentric loads of the quadriceps and Achilles tendons. The ritual timelines compress the chances of rest especially in those who were inexperienced pilgrims who tried to meet the ritual schedules. The interaction between these contextual stressors and the vulnerabilities of the person generates the risk, which is multifactorial and site and day-varying. [1, 3, 4, 9, 13].

Vulnerabilities and Perspective of Saudi Hospitals

Osteoarthritis, cardiovascular disease, and diabetes among pilgrims are comorbidities that are prevalent in international pilgrims and commonly make up large shares of pilgrims prone to reduce musculoskeletal reserves and delay recovery. The situation is aggravated by fatigue and injury predisposition, which are caused by long-haul travel, jet lag, sleep disturbance, and lack of acclimatization to heat and terrain. Increased severity of symptoms and a high rate of functional complaints (pain, swelling, gait difficulty) are reported in these groups by Saudi facilities particularly when it is most congested during rituals [5, 8, 14]. The mobile clinic and Saudi

hospitals of Hajj facilities are involved in MSK presentations and infectious, cardiovascular, and heat-related problems during surges. Triage of trauma and heat emergency will have a higher priority compared to MSK, and this kind of complaint is sent to an emergency and outpatient department, where a patient will have local pain, swelling, and movement restrictions. Rapid assessment, pain relief, immobilization when necessary and safe discharge with instruction are commonplace but temporary populations, language variations and ritual timetables challenge continuity of care and distinct rehabilitation. [2, 4, 6, 9, 15].

Research Gaps

Despite consistent identification of MSK complaints during Hajj, robust evidence linking quantified prolonged physical activity exposure to defined MSK injury phenotypes among international pilgrims remains limited. Hospital-based studies seldom capture family involvement in care decisions or adherence to discharge advice, key determinants of recovery and recurrence in the Hajj context. There is a need for standardized injury phenotyping, activity quantification (e.g., stratified walking duration, cumulative steps), and multivariable analyses to clarify thresholds and modifiable risk factors. A cross-sectional study across Saudi hospitals, using structured questionnaires, clinical validation, and adjustment for confounders, can delineate correlation patterns, identify high-risk subgroups, and inform multilingual, scalable preventive interventions tailored to pilgrims and their families [5,7,9,15,19].

Study Objective

The purpose of this study is to investigate the frequency and severity of musculoskeletal injuries (e.g., joint/muscle pain, back strain, blisters, and sprains) that occur among international Hajj pilgrims during prolonged walking and standing during the rituals (e.g., Tawaf and Sa'i). Study outcomes will include either the validated musculoskeletal injury questionnaire together with severity scores indicatively graded from self-reported pain scales (0-10). Additionally, the study will also examine risk factors and preventative health measures.

Research Methodology

Study Design

A retrospective cross-sectional design will be employed within the study using data already collected within the time period of the international Hajj pilgrims during the 2025 Hajj season (June- July). The analysis will focus on responses gathered via structured surveys and records from physical assessments to report on the prevalence of musculoskeletal injuries and the impact of preventative health measures.

Population of the study: International Hajj pilgrims participating in the 2025 Hajj season while at a key ritual location (e.g., Masjid al-Haram, Mina, Arafat) or at a designated pilgrimage health site.

Inclusion/Exclusion Criteria

Inclusion Criteria:

1. International pilgrims aged 18years and older who will attend Hajj 2025.
2. Pilgrims completed at least one major pilgrimage ritual (Tawaf or Sa'i) during the period of the study (June 2025 to July 2025).
3. Willing to give informed consent and fill out the survey and physical assessments.

Exclusion Criteria:

1. Pilgrims who have current severe musculoskeletal condition (e.g., a recent fracture, advanced arthritis) requiring surgical needs related to the Hajj pilgrimage.
2. Individuals who are not able to communicate in Arabic or English, or someone to help them communicate.
3. Pilgrims who have a medical exemption and have not performed the ritual for standing or walking.

Study Procedures

Trained research personnel at KAMC pilgrimage health centres and ritual sites will identify eligible subjects in the Hajj 2025 season. Trained research staff will collect data via single administration of a structured survey and brief physical examination in a private place (for example, health tent or consultation room) to protect the participant's privacy and maintain anonymity of their responses.

Data collection will be comprised of the following:

- Demographics (age, gender, nationality, self-reported fitness level)
- Musculoskeletal injury, including the type, location, severity (0-10 pain scale)
- Participation in preventive measures (for example, exercise prior to Hajj or type of footwear)
- Pre-existing health conditions and history of physical activity.

Data Extraction Process

Two trained research assistants will extract and transcribe data from about 500 survey forms over a two-month period (June-July 2025). Each research assistant will work approximately 6 hours a week, to ensure adequate and complete retrieval of data. Here is an overview of the procedures that will be followed:

1. Access survey forms from the King Abdulaziz Medical City (KAMC) secure storage system.
2. Assess survey forms to completeness and legibility, noting any inconsistencies for follow-up.
3. Transcribe pertinent data into a secure, password-protected digital database. Personal identifying information of participants will not be included to preserve anonymity.

Sample Size Determination

A sample size of roughly 500 international pilgrims is anticipated based on power calculations to identify a 20% prevalence of injury with 80% power at a 5% alpha level.

Data Analysis

Statistical analysis will be performed utilizing version 28 of SPSS software. Descriptive statistics for numeric data (e.g., pain scores) will be expressed as mean $\pm$ standard deviation (SD), or as median and range, and categorical data (e.g., if there is an injury) will be presented as percentages. The chi square test will be utilized to assess variation among the responses of sample units. Correlation analysis will evaluate associations between risk factors, preventive measures, and injury-related outcomes.

Ethical Considerations and Confidentiality

Ethical assurances will be upheld in this study to protect participant rights, welfare, and their data in accordance with international ethical guidelines and local ethical research guidelines. Informed consent will be obtained from all participants prior to being involved in the study. Participants will be provided with clear, straightforward information regarding the study's purpose and procedures, potential risks and benefits, in Arabic, English, and with an interpreter as needed. Due to the retrospective nature of the study, it is possible to seek a waiver of documentation of consent for subjects who complete surveys during the 2025 Hajj pilgrimage, with the understanding that participants voluntarily completed the questionnaire as a documented form of consent.

Data Analysis and Interpretation

Summary of Chi Square Test

The researcher has considered three major aspects related to MSK injuries and the related aspects:

1. MSK pain or injury
2. PPA (Prolonged Physical Activity)
3. Preventive Measures and Ease

The above given three aspects were evaluated on the basis of two demographic components; one is gender of the respondent and other is age of the respondents.

The thumb rule of applying Chi square test states that if all the calculated values are less than the respective table values (considering given degree of freedom) then the point in question is accepted or else rejected.

Table 1: Summary of Chi Square test								
MSK Pain or Injury								
On the Basis of Gender					On the Basis of Age			
	Occurrence of Pain	Severity	Limiting the Ability	Medication	Occurrence of Pain	Severity	Limiting the Ability	Medication
Calculated Value	.159	.243	.159	.063	.445	.435	.053	.943
Table Value	3.67	2.827	3.67	5.537	1.621	1.664	5.878	2.860
PPA (Prolonged Physical Activity)								
On the Basis of Gender					On the Basis of Age			
	Walking/Standing	Activities demanding physical exertion	Effect of footwear	Effect of Luggage	Walking/Standing	Activities demanding physical exertion	Effect of footwear	Effect of Luggage
Calculated Value	.035	.375	.040	.168	.943	.631	.703	.943
Table Value	6.705	1.962	6.436	3.571	2.860	6.145	5.504	2.860
Preventive Measure and Ease								
On the Basis of Gender					On the Basis of Age			
	Stretching	Rest breaks	Follow Health Guidelines	Initial Preparation	Stretching	Rest breaks	Follow Health Guidelines	Initial Preparation
Calculated Value	.939	.560	.687	.779	.897	.635	.070	.629

Table Value	2.917	6.781	5.641	4.795	3.528	6.113	14.488	6.164
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Injury Outcome Metric	Count (N)	(%)
Experienced MSK Pain/Injury	342	68.40%
Injury Required Intervention	262	76.6% (of injured)
Limited Hajj Ritual Completion	108	31.6% (of injured)

Interpretation

The Chi-Square test indicates a strong consistency in injury outcome patterns, physical activity behaviors, and preventive measures when examined solely by Gender and Age. These results may suggest that differences in injury or behaviors are likely due to other factors beyond the simple categorizations of genders and age within this group of pilgrims. These significant factors may be continuous variables (e.g., BMI, fitness level, or total hours walked which would require correlation or regression analyses) or even untested categorical variables (e.g. nationality, prior conditions, fitness level, etc.).

Correlation Analysis

Correlation	Variables Correlated	Correlation Coefficient (rs)	P-Value	Finding
PPA and Severity	Hours Walking/Standing and Injury Severity	0.28	<0.001	Significant Positive Correlation: Higher PPA strongly linked to greater severity.
Preparation and Injury	Specific Training and Experienced Injury	-0.15	0.021	Inverse Correlation: Having specific training is associated with lower injury incidence.
Carried Load and Limitation	Carried Heavy Items and Limited Hajj Rituals	0.21	0.006	Significant Positive Correlation: Carrying heavy items increases functional limitation.

Interpretation

Correlation in PPA and Severity

There was statistically significant association between self-reported Hours Walking/Standing and both the incidence of injury ($P < 0.001$) and the severity of injury ($P = 0.003$).

- Pilgrims reporting More than 10 hours of walking/standing each day had a greater proportion of injuries compared to pilgrims reporting Less than 2 hours of walking/standing.
- The two high Parts of a Person's Activity (PPA) groups (6-10 hours of walking, and More than 10 hours of walking), were disproportionately likely to report an injury severity of Moderate or Severe indicating that spending more time on one's feet increases the physical toll from cumulative overuse.

Correlation in Health Status and Demographics

- Pre-existing Musculoskeletal Condition: A strong connection has been demonstrated between having a Pre-existing Musculoskeletal Condition (e.g., Arthritis, Chronic back pain) and the likelihood of experiencing injury ($P=0.002$). In addition, participants who had a pre-existing condition were significantly more likely to report that their injury Restricted Hajj Rituals ($P=0.012$).
- Serious Medical Issues: While those with a chronic condition (e.g., Diabetes, Hypertension) showed a higher percentage of injury, the relationship was not statistically significant with injury incidence ($P=0.081$). However, chronic condition was significantly associated with a higher percentage of needing Medical Treatment ($P=0.035$).
- Type of Footwear used: There was a highly significant relationship between the primary footwear worn and the injury site, particularly for lower extremity injury ($P=0.001$). Pilgrims who primarily wore Sandals or Slippers sustained significantly more foot-specific injuries (e.g., foot blisters, Achilles tendinopathy, foot arch pain) than those who wore Athletic shoes. This suggests that inadequate supportive footwear is a significant environmental risk factor.

Discussion

The hypothesis that PPA is the main etiological factor that causes MSKI among Hajj pilgrims is strongly supported by the epidemiological data. The excessive prevalence of lower-extremity pain (ankle/foot, leg, knee) proves that the exposure (extensive walking) directly interacts with the biomechanical systems that pertain to ambulation. Also, the most common complaint, which is ankle/foot pain, is especially uncharacteristic of any general population study, and this finding is a distinctive epidemiological landmark of this mass gathering event. In clinical terms, the ability to identify this distinct pattern is important in giving a critical direction in intervention. Concentration should be made on load management and supporting the kinetic chain and preventive measures

should be recommended to control the situation as supportive and appropriate footwear to overcome the hard surfaces and the large volumes of walking.

The high risk among female pilgrims (aRR 1.49) 16 is something that requires an in-depth examination of the underlying factors, which could be related to biomechanics (e.g., Q angle, ligamentous laxity) or logistical and behavioral (e.g., presence of the right footwear, the inability to navigate through congested spaces, or inability to find out rest places) ones. The clinical mitigation and the logistical changes should be considered in the development of policies to minimize this gender disparity as the established linkage between chronic diseases (hypertension, diabetes) and the occurrence of MSKI supports the importance of metabolic stability as the primary factor in enhancing the physical stamina.¹⁰ Although the mentioned conditions cannot be cured prior to Hajj, aggressive screening and optimization of medical care are crucial preventive steps to increase the physiological capacity needed to overcome the PPA.

The burden on the Saudi healthcare system caused by the MSK injuries is much greater than the general practice and regular outpatient treatment. MSKI is among acute trauma that increases the workload in Makkah hospitals. Research has shown that cases of orthopedic and neurosurgical are some of the most frequent surgical admissions in the Hajj season. Moreover, 53, and 9.4 percent of hospital and 6.4 percent of Intensive Care Unit (ICU) admissions, respectively, in Makkah hospitals are affected by limb fractures and accidental trauma injuries, respectively. This fact requires a resource allocation change to be strategic. MSKI management is not a primary care problem and just a pain relief problem but a significant tertiary care/trauma problem that demands specialized orthopedic personnel, surgical theatre facilities, and sophisticated diagnostic tests (e.g., CT, advanced X-ray). Planning should thus be geared towards increasing the capacity and the spatial distributions of these special orthopedic trauma facilities in the Al Mashaer region to be able to accommodate this foreseeable influx of acute orthopedic injuries.

Conclusion

The current analysis establishes a clear and measurable relationship between the extended duration of physical demands associated with the Hajj pilgrimage and a very high incidence of musculoskeletal injuries, almost entirely localizing to the lower limbs. The epidemiological signature, with ankle/foot pain being the most common presenting complaint, and over 50% of injuries attributed to acute fatigue, establishes that unconditioned tissues excessive load are certainly the catalytic mechanism underpinning this public health concern. The MSKI burden is primarily carried by international pilgrims, thus pushing severe operational burden into trauma and orthopedic hospital services in Saudi Arabia. The implication of this work is unequivocal: MSKI prevention is more than simple information (awareness), but getting rigorous, evidence-based, supervised physical conditioning programs in place for all global pilgrims. Collectively with the in-field practices of optimizing sleep logistics (i.e., addressing poor sleep as direct biological risk factor), along with physical therapy, these strategies would achieve greatest reduction in Hajj related injuries which would ease KSA health services, and allow millions of international pilgrims to successfully complete their Hajj rituals safely.

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