The prevalence and associated risk factors of musculoskeletal pain among pilgrims during the Hajj: cross-sectional results from 59 nationalities

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Abstract

Background: Musculoskeletal pain is a major burden on individuals, social and healthcare systems. Annually, 2–3 million pilgrims perform the Hajj in Mecca, Saudi Arabia. The Hajj involves a high level of physical demand because pilgrims generally move by foot for long distances among a series of religious sites, an effort that may exceed the typical physical activity level for most individuals. To understand the impact of musculoskeletal pain on the completion of the Hajj, it is first necessary to evaluate the extent of the problem. This study aimed to estimate the point prevalence of musculoskeletal pain and associated risk factors among pilgrims.

Methods: A cross-sectional survey was conducted during the period of the Hajj. Data were collected after completion of the 2 nd day of the Hajj (21–31 August 2018), mainly by volunteers using an online application or paper form and approaching individuals at different sites around Mecca. The main inclusion criteria were as follows: adult pilgrims aged 18 or older. Participants were allowed to report more than one site of pain. Prevalence and odds ratios were calculated.

Results: A total of 1,715 responses were included in the data analysis. The prevalence of musculoskeletal pain was high (82.27%). Musculoskeletal pain was most commonly reported in the ankle/foot (39.07%), leg (30.38%), lower back (28.40%), knee (23.03%) and shoulder (16.09%). The odds ratios revealed that musculoskeletal pain was more common in females; older individuals; individuals who smoked, had diabetes or hypertension; those who believed that the Hajj was physically exhausting and those who had experienced a fall during the Hajj. However, there were variations in the degrees of importance of these factors across different anatomical sites of the pain.

Conclusions: Musculoskeletal pain is common among pilgrims, and it is more prevalent among pilgrims than among the general population. Unlike most populations examined in other studies, ankle/foot and leg pain were the most common in pilgrims. These data provide guidance for potential preventative programs and the allocation of resources to optimise pilgrims' experiences and ability to complete the Hajj.

Trial registration: The study was registered at https://www.researchregistry.com in August 2018 (No. 4352).

Background

Musculoskeletal pain is common and imposes a major burden on individuals, as well as social and healthcare systems [1, 2]. It affects both sexes of all ages across all socio-cultural groups [1, 3]. Musculoskeletal pain is considered to be one of the most common causes of pain and physical disability, and it impacts hundreds of millions of people around the world. It is also the leading global contributor to disability, with lower back [4, 5] and neck [4] pain collectively being the single leading cause of disability.

Musculoskeletal pain predominantly develops over time, causing further hyperalgesia and larger areas of pain [2]. The prevalence of musculoskeletal pain is rising, and it has been described as an epidemic [1, 6]. Furthermore, the occurrence and chronicity of musculoskeletal pain have been associated with multiple risk factors, such as obesity, anxiety, depression, reduced physical activity, physical restrictions and job dissatisfaction [7–10], which contribute to increased morbidity and mortality.

"Hajj" is an Arabic word that means "pilgrimage" [11]. The Hajj is the largest annual pilgrimage in the world, and it is undertaken by Muslims at least once in their lifetime as a religious duty [12–15] if they are financially and physically capable [16]. Every year, around two to three million pilgrims converge simultaneously on the holy city of Mecca in Saudi Arabia for the rites of the Hajj, and they perform a series of identical rituals [13, 14, 16, 17] that were originally performed by the Prophet Mohammed [13]. Based on the lunar Islamic year/calendar, the Hajj begins on the 8th day of Dhu al-Hijjah (the last month of the Islamic year) and ends on the 12th day of the same month [14, 16], but some may spend further days to complete the Hajj [15]. The date of the Hajj differs with respect to the Gregorian calendar, which occurs 11 days earlier every sequential year [12].

This mass gathering, combined with the extreme congestion in small areas, may contribute to one of the most important public health problems in the world [13, 18], which poses high environmental and healthcare demands. The Hajj also involves high physical demands because pilgrims move, generally by foot, among a series of religious sites over 5–7 days while following a specific route with distances of an average of 5–15 km/day [12, 15, 19] and may reach to a total of 63 km distance during the whole period of the Hajj [20]. This likely exceeds the typical physical activity exposure for most individuals and is further complicated by overcrowding, extreme heat and fatigue [11, 13, 15, 21]. As an example, during the Hajj, temperatures can be range from 37–45 °C (98.6–113°F) [11, 21] and sometimes 24–37 °C (75.2–98.6°F) [15]. Most pilgrims stay in camping tents during the entire Hajj period [11, 16], whereas some pilgrims, who cannot afford to pay for a stay in camping tents, often stay outdoors [16]. In addition, the normal life routine of individuals is possibly changed as they move between places where the geography and climate are different, or those individuals may neglect their self-health management while they are preoccupied with religious rituals [11]. Free health services are provided to pilgrims by the Ministry of Health of Saudi Arabia [16]. As a

result, Saudi healthcare systems attempt to obtain all necessary data about the patterns of disease and complications to help control the diseases and consequently provide the pilgrims with the best care when needed.

Many studies have been conducted to investigate health issues in pilgrims, with the main focus on infectious diseases [13–16, 18, 22, 23], as well as other diseases, including cardiovascular diseases, neurological disorders, trauma, gastrointestinal problems, diabetes, heat exhaustion and dermatological diseases [11, 14, 18, 19, 24–27]. However, the prevalence of musculoskeletal pain and the potential associated risk factors among pilgrims during the Hajj have not been investigated. This makes it difficult to determine the impact of musculoskeletal pain in those individuals who undertake the Hajj. It is unclear whether the musculoskeletal pain among pilgrims is more important and prevalent in some anatomical sites than in others and whether the pain in these anatomical sites is associated with specific risk factors that should be taken into account. It also is unclear whether there is a specific sex or age group with a higher risk of musculoskeletal pain than others.

In summary, to understand the potential impact of musculoskeletal pain on completion of the Hajj, the development of preparatory advice and the preparation of support services, it is first necessary to evaluate the extent of the problem. Therefore, this study aimed to estimate the point prevalence of musculoskeletal pain by anatomical site among pilgrims and to study potential associations with individual characteristics (e.g., sex and age), history of major medical conditions (e.g., diabetes and hypertension), beliefs about the Hajj and falls during the Hajj.

Methods

Study design

A cross-sectional survey with convenience sampling was utilised to estimate the point prevalence of musculoskeletal pain among pilgrims during the Hajj. Ethical approval was obtained for the study from the Physiotherapy Research Committee of the Faculty of Applied Medical Sciences at Umm Al-Qura University in Mecca, Saudi Arabia. This study was registered at https://www.researchregistry.com in August 2018 (Research Registry Identifying Number: 4352).

Participants

The participants of this study were adult pilgrims aged 18 or older. All nationalities were considered in this study, whether they were originally from Arabic or non-Arabic countries. The Hajj can only be performed on specific days on the last month of each year according to the Hijri/Islamic calendar [13]. In this study, all participants had performed the Hajj in August 2018, which corresponded with Dhu al-Hijjah 1439 of the Hijri/Islamic calendar. Any participants who had performed Umrah were excluded because Umrah involves some similar religious tasks, but it is different from performing the Hajj (Umrah is considered a sunnah, and it is not one of the religious duties in Islam; it can be performed at any time of year, and it takes only a couple of hours to be completed [13]). Furthermore, all individuals who were working to serve and provide services—such as transportation, safety, social care, drifters care or healthcare—to pilgrims in all the religious sites in Mecca that pilgrims may visit, who did not perform the Hajj themselves, were excluded. All included participants read the informed consent form and agreed to participate.

Data collection

The data were collected after completion of the 2nd day of the Hajj from 21 to 31 August 2018 (10 to 20 Dhu al-Hijjah 1439 of the Hijri/Islamic calendar). The main method used to collect the data was by healthcare professional volunteers, who approached individuals at different sites of Mecca—including Muzdalifah, Mina and holy mosque sites—using an online application or a paper form or through Hajj camps/organisations that were located around the religious sites. Furthermore, the survey was available on social media platforms, but this was restricted to those who had performed the Hajj during the specified period mentioned above.

The data from the online application were collected through an online survey using a validated website (www.surveymonkey.com). The collected data from the paper form were uploaded to the online application by the authors in order to obtain one single master file for both methods (online application or paper form). All information collected was anonymous, and only the authors had access to the data.

Survey

The data of the survey were sequentially collected (one by one) to avoid response bias in the same sequence listed below. The survey was provided in two versions: an Arabic version and an English version. Moreover, some of the volunteers spoke other languages than Arabic and English and helped translate the survey content to pilgrims who were interested in participating but did not properly understand Arabic or English. The structure of the survey used in this study was as follows:

- Demographics: Participants were asked to answer questions about their nationality/country, sex, age and body mass index (BMI).
- Major medical history: Participants were asked about previous medical history, such as smoking, diabetes and hypertension.
- Beliefs about the Hajj: Participants were asked about their beliefs about the Hajj and whether they believe that the Hajj is physically exhausting.
- Prevalence of falls: Participants were asked if they had lost their balance and fallen during the Hajj to estimate the point prevalence of falls.
- Prevalence of musculoskeletal pain: Participants were asked if they had experienced musculoskeletal pain or discomfort (by anatomical site) during the Hajj. All participants were allowed to report more than one site of pain.
- Treatment: Participants were asked if they had received a treatment or had seen a doctor because of the musculoskeletal pain they felt during the Hajj.

Power analysis

According to a statistical report conducted by the Saudi General Authority for Statistics in 2017, the total number of pilgrims who visited the holy city of Mecca in Saudi Arabia to perform the Hajj in 2017 was 2,352,122. This estimated number includes Saudi (n = 209,415) and non-Saudi (n = 2,142,707) pilgrims [28]. Based on this information, it was assumed that around 2–3 million pilgrims would come to SA to perform the Hajj in 2018. Thus, the sample size was calculated by setting the statistical power at a 99% confidence interval, with a population size of 3,000,000 and a margin of error of 5%, indicating that the required sample size for this study was 666 participants. After the completion of the Hajj 2018, the Saudi General Authority for Statistics revealed that the total number of pilgrims who performed the Hajj in 2018 was 2,371,675 [17], this estimation was within our assumed range of the total number of pilgrims to perform the Hajj in 2018 (2–3 million).

Statistical analysis

The percentages and frequencies of participants' responses for demographics and major medical history were recorded and analysed. The percentages and frequencies of nationalities were also recorded and presented as a geographic figure to observe the distribution of the data among countries.

The point prevalence of musculoskeletal pain (pain at any anatomical site), spine musculoskeletal pain (pain at any anatomical site of the spine), upper limb musculoskeletal pain (pain at any anatomical site of the upper limb), lower limb musculoskeletal pain (pain at any anatomical site of the lower limb) and musculoskeletal pain for each anatomical site were calculated separately.

It is crucial to have a broad picture of the basic epidemiological data on sex- and age-based differences in musculoskeletal pain and allow a proper adjustment [29–31]. This will contribute to a better understanding of the prevalence of musculoskeletal pain and subsequently contribute to the promotion of appropriate prevention and management strategies for musculoskeletal pain. Furthermore, the use of comparable prevalence estimates is necessary for a pragmatic description of the extent of the problem [30]. Thus, this study calculated the point prevalence of musculoskeletal pain for each anatomical site among different age groups for males and females to identify any significant associations using a Pearson's chi-squared two-tailed test. The results of the point prevalence of musculoskeletal pain are presented as percentages (%) with 95% confidence intervals (CIs). The pilgrims' beliefs about the Hajj, the point prevalence of falls and the proportion of pilgrims who received treatment during the Hajj were also calculated for each age group and for males and females.

The odds ratio (OR) for musculoskeletal pain was calculated to measure the association between an exposure and an outcome, to identify whether a specific exposure is a risk factor for a specific outcome and to compare the magnitude of different risk factors for that outcome [32]. The result of the OR can be interpreted in 3 ways [32]: exposure does not affect the odds of the outcome (OR = 1), exposure is associated with higher odds of the outcome (OR > 1) and exposure is associated with lower odds of the outcome (OR < 1). The 95% confidence interval (CI) was also calculated to estimate the precision of the OR, where a larger 95% CI indicates a lower level of precision of the OR, whereas a smaller 95% CI indicates a higher precision of the OR [32]. The estimation of OR was adjusted for sex and age to control confounding effects [33]. The adjusted OR was calculated using multinomial logistic regression analysis, in which sex was age adjusted, age was sex adjusted, and all others were sex–age adjusted. The adjusted OR was used to identify significant differences in demographics, major medical history, beliefs about the Hajj, the point prevalence of falls and the reception of treatment between pilgrims who reported musculoskeletal pain (musculoskeletal pain, shoulder pain, upper arm pain, elbow pain, forearm pain, wrist/hand pain, head pain, cervical pain, thoracic pain, lumbar pain, hip/pelvis pain, thigh pain, knee pain, leg pain, ankle/foot pain) and those who did not.

Incomplete responses were discarded when there were no data available about the prevalence of musculoskeletal pain. The findings were considered statistically significant when $P < 0.05$. The data were analysed using IBM SPSS version 24 (Armonk, NY: IBM Corp).

Results

Characteristics of the pilgrims

A total of 2,110 responses were received in the study, of which 1,715 had complete information for all the survey sections (81.28%). Data from 59 nationalities were recorded, 84.72% from Arabic countries and 15.28% from non-Arabic counties. The majority of Arabic participants were from Saudi Arabia, Egypt and Syria, whereas most non-Arabic participants were from the United Kingdom, Pakistan and France. The number of participating male pilgrims (53.64%) was slightly higher than that of the female pilgrims (46.36%). Most of the participating pilgrims were under 40 years old (59.53%). Some of the pilgrims were smokers (22.04%), had diabetes (14.34%) and hypertension (18.13%). The largest difference between males (83.60%) and females (16.40%) was observed for the smoking variable. Figure 1 presents the nationalities/countries of all participating pilgrims. Table 1 shows the demographic data and major medical history of the participants.

Proportion of pilgrims who believed that the Hajj was physically exhausting

Approximately half of the pilgrims believed that the Hajj is physically exhausting (44.43%). This belief was more common in older pilgrims than in younger pilgrims. The largest difference between males and females was observed in pilgrims aged between 30 and 39 years. Figure 2 shows the proportion of pilgrims' beliefs about whether the Hajj was physically exhausting by sex and age.

Point prevalence of falls

The point prevalence of falls was relatively high (13.76%), and the prevalence was higher in females (15.97%) than in males (11.85%). The prevalence of falls was higher in older pilgrims than in younger pilgrims. The largest difference between the males and the females was observed in pilgrims who were older than 60. Figure 3 shows the point prevalence of falls among pilgrims by sex and age.

Point prevalence of musculoskeletal pain

The point prevalence of musculoskeletal pain (pain at any anatomical site) was high (82.27%). The point prevalence of musculoskeletal pain for the spine, upper limbs and lower limbs was 46.71%, 23.27% and 66.41%, respectively. The most prevalent musculoskeletal pain among pilgrims was ankle/foot pain (39.07%), followed by leg pain (30.38%), low back pain (28.40%), knee pain (23.03%) and shoulder pain (16.09%). The prevalence of musculoskeletal pain was higher in female pilgrims than in males. The largest difference between males and females was observed for low back pain (males: 25.11%, females: 32.20%), followed by leg pain (males: 27.17%, females: 34.09%). The prevalence of musculoskeletal pain was higher in older pilgrims than in younger pilgrims at multiple pain sites. The largest difference between younger and older pilgrims was observed for knee pain (18–29: 14.75%, ≥ 60: 41.77%), followed by low back pain (18–29: 25.59%, ≥ 60: 37.97%) and leg pain (18–29: 30%, ≥ 60: 41.14%). Whereas, ankle/foot pain was more common in the younger (18–29: 42.71%) than in the older (≥ 60: 36.08%) pilgrims. Figure 4 shows the point prevalence of musculoskeletal pain by anatomical site. Figure 5 shows the point prevalence of musculoskeletal pain by anatomical site and sex. Figure 6 shows the point prevalence of musculoskeletal pain by anatomical site and age.

For male pilgrims, there were significant differences ($P < 0.05$) between the age groups in terms of neck pain, low back pain, forearm pain, wrist/hand pain, hip/pelvis pain, knee pain and leg pain. For female pilgrims, there were significant differences ($P < 0.01$) between the age groups in terms of hip/pelvis pain, thigh pain and knee pain. There was also a significant difference ($P < 0.01$) between the age groups in terms of musculoskeletal pain (pain at any anatomical site) prevalence, but only in male pilgrims. Table 2 shows the age-based differences in musculoskeletal pain in males and females.

Proportion of pilgrims who received treatment during the Hajj

Several pilgrims received treatment due to the musculoskeletal pain they felt during the Hajj (24.31%). The proportion of those who received treatment belief was higher in older pilgrims than in younger ones. The largest difference between males and females was observed in pilgrims aged 40 and 49 and 50 and 59 years. Figure 7 shows the proportion of pilgrims who received treatment during the Hajj by sex and age.

Odds ratio for musculoskeletal pain

Musculoskeletal pain (pain at any anatomical site)

Multinomial logistic regression analyses indicated that musculoskeletal pain was more common in females ($P < 0.001$), older individuals aged between 40 and 49 ($P < 0.05$), 50 and 59 ($P < 0.01$) or ≥ 60 ($P < 0.01$) years, individuals who smoked ($P < 0.001$), had diabetes (P <

0.001) or hypertension (P < 0.001), those who believed that the Hajj was physically exhausting (P < 0.001), those who had experienced a fall during the Hajj (P < 0.001) and those who received treatment during the Hajj (P < 0.001). There was no significant association between BMI and musculoskeletal pain. Table 3 shows the odds ratio with 95% CI for musculoskeletal pain.

Musculoskeletal pain of the spine

Multinomial logistic regression analyses indicated that head pain, neck pain and low back pain were more common in females (all, P < 0.05). Low back pain was more common in pilgrims aged over 60 years than in those younger than 30 years (P < 0.01). Pain in the head and neck was less common (all, P < 0.05) in obese pilgrims (BMI: ≥30) whereas pain in the lower back was more common in obese pilgrims (P < 0.05) than in pilgrims with a normal weight (BMI: 18.5–24.9). Pain at all spinal sites was more common in individuals who smoked (all, P < 0.05), those who believed that the Hajj was physically exhausting (all, P < 0.01) and those who received treatment during the Hajj (all, P < 0.05). Pain in the head and neck (all, P < 0.05) and lower back (close to the margin of significance, P = 0.055) was more common in those who had diabetes, whereas pain in the neck and lower back was more common in those who had hypertension (all, P < 0.01). Pain across all spinal sites (except the lower back) was more common in individuals who had experienced a fall during the Hajj (all, P < 0.05) Table 4 shows the odds ratios with 95% CIs for musculoskeletal pain of the spine.

Musculoskeletal pain of the upper limb

Multinomial logistic regression analyses indicated that shoulder pain was more common in females (P < 0.01) and those who believed that the Hajj was physically exhausting (P < 0.001). Pain in the elbow, forearm and wrist/hand was more common in pilgrims aged between 50 and 59 years compared to those younger than 30 years (all, P < 0.05). Pain in the shoulder (close to the margin of significance, P = 0.055) and upper arm (P < 0.05) was more common in underweight pilgrims (BMI:<18.5) than in those with a normal weight (BMI: 18.5–24.9). Pain in the upper arm and wrist/hand was also more common in individuals who smoked (all, P < 0.05). Pain in the shoulder, upper arm, wrist/hand (all, P < 0.01) and forearm (close to the margin of significance, P = 0.052) was more common in individuals who had diabetes. Pain in the shoulder, elbow and wrist/hand was more common in individuals who had hypertension (all, P < 0.01). Pain in all upper limb sites was more common in individuals who had experienced a fall during the Hajj (all, P < 0.05). Pain in all upper limb sites (except the forearms) was more common in individuals who received treatment during the Hajj (all, P < 0.05). Table 5 shows the odds ratios with 95% CIs for musculoskeletal pain of the upper limb.

Musculoskeletal pain of the lower limb

Multinomial logistic regression analyses indicated that pain in all lower limb sites (except the thigh) was more common in females (all, P < 0.05). Pain in the hip/pelvis, knee and leg was more common in pilgrims aged over 60 years than in those younger than 30 years (all, P < 0.01). Knee pain was the only pain in the lower limb that was more common in individuals who smoked (P < 0.05). Pain in the knee and ankle/foot was more common in individuals who had diabetes (all, P < 0.01). Pain in the hip/pelvis and knee was more common in individuals who had hypertension (all, P < 0.05). Pain in all lower limb sites (except the hip/pelvis) was more common in individuals who believed that the Hajj was physically exhausting (all, P < 0.000). Pain in the hip/pelvis was the only pain that was more common in individuals who had experienced a fall during the Hajj (P < 0.000). Pain in the knee and ankle/foot was more common in individuals who received treatment during the Hajj (all, P < 0.01). There was no significant association between BMI and musculoskeletal pain in any anatomical sites of the lower limb. Table 6 shows the odds ratios with 95% CIs for musculoskeletal pain of the lower limb.

Discussion

This study found that most pilgrims were at a high risk of experiencing musculoskeletal pain during the Hajj. The most prevalent forms of musculoskeletal pain among pilgrims were ankle/foot pain, leg pain, low back pain, knee pain and shoulder pain. The findings of this study confirmed significant associations between the prevalence of musculoskeletal pain and demographics, major medical history, beliefs about the Hajj, falls and receiving treatment during the Hajj.

Musculoskeletal pain (pain at any anatomical site)

The majority of pilgrims (82.27%) had at least 1 musculoskeletal complaint during the Hajj. This high prevalence rate was in consistent with the findings of previous studies among different populations, such as occupational drivers in Nigeria (89.31%) [34], the working population in New Zealand (92%) [35], nursing assistants in Norway (88.8%) [36], physiotherapists in India (88%) [37], dentists in Iran (73.17%) [38] and Greece (62%) [39], agricultural farmers in Nepal (70%) [40] and bariatric surgeons around the globe (66%) [41]. Our findings differ from those of studies that reported lower rates of musculoskeletal pain, such as the general population in the Netherlands (53.9%) [42], construction workers in Saudi Arabia (48.48%) [43], the Quebecois working population in Canada (41.43%) [44], the older population in the United States (40%) [45] and the general populations in Sweden (23.9%) [46], Brazil (21.6%) [47] and Japan (15.38%) [48].

The prevalence of musculoskeletal pain (pain at any anatomical site) in the current study was greater in females and older individuals. These findings are consistent with those of previous studies that reported a higher prevalence of musculoskeletal pain in females than in males in Brazil [47], Japan [48], Sweden [46], the United States [45] and worldwide [49, 50]. Furthermore, several studies have yielded findings similar to ours, revealing that age is a risk factor for musculoskeletal pain. These studies reported that musculoskeletal pain was more common in individuals aged ≥ 60 years than in younger individuals in different countries [46, 47, 50]. However, our findings differ from those of studies that found either no significant association between age and musculoskeletal pain [35, 43] or that adults had a higher risk of musculoskeletal pain than individuals over 60 years old among the general population in Japan [48]. There was no significant association between BMI and musculoskeletal pain among pilgrims in our study, whether with a crude or an adjusted OR. This result was similar to that of a study conducted among construction workers in Saudi Arabia, which found no association between BMI and musculoskeletal pain [43]. On the other hand, our findings differ from those of Bezerra et al. (2018) [47] and Abdulmonem et al. (2014) [51], who reported that musculoskeletal pain was more common in those with greater BMIs than in those with a normal weight in Brazil [47] and Saudi Arabia [51]; however, these studies did not adjust for potential confounding factors.

In the current study, musculoskeletal pain was more common overall in individuals who smoked, had diabetes and hypertension, believed that the Hajj is physically exhausting, had experienced a fall during the Hajj and/or had received treatment during the Hajj. These findings were in consistent with some other previous studies reporting that smoking [47], diabetes [27], depression [45, 47] and falls [45] were risk factors for musculoskeletal pain among the general and older populations. However, our study differs from a few studies that did not find significant difference between smokers and non-smokers in terms of musculoskeletal pain among construction workers in Saudi Arabia [43]. Our study also found that 24.31% of pilgrims obtained medical care due to the musculoskeletal pain they felt during the Hajj. This result was similar to those of studies that found a significant proportion of the individuals with musculoskeletal pain among diverse populations reported seeking medical care [39, 41–43].

Sex- and age-based differences in musculoskeletal pain prevalence

In our study, the largest difference between males and females was observed for low back pain (males: 25.11%, females: 32.20%) and leg pain (males: 27.17%, females: 34.09%) among pilgrims. There are large demographic differences for most anatomical sites of pain, with the largest differences being between males and females in the literature. In the Netherlands, the largest differences between males and females were observed for neck pain (males: 15.7%, females: 25.4%) and shoulder pain (males: 16.2%, females: 25.6%) among the general population [42]. In Canada, the largest difference between the sexes was observed for neck pain (males: 11%; females: 18%) among the Quebecois working population [44]. In New Zealand, the largest differences between males and females were observed for upper back pain (males: 15%, females 23%) and shoulder pain (males: 38%, females 46%) among the working population [35]. In Norway, the largest sex-based difference was observed for hip pain (males: 16.2%, females: 27.1%) and shoulder pain (males: 36.8%, females: 47.5%) among nursing assistants [36].

In our study, the prevalence of musculoskeletal pain was higher in older pilgrims than in younger pilgrims at multiple pain sites. The largest difference between younger and older pilgrims was observed for knee pain (18–29: 14.75%, ≥ 60: 41.77%) and low back pain (18–29: 25.59%, ≥ 60: 37.97%). These findings differ from those of previous studies in the literature. In the Netherlands, the largest differences between younger (25–44) and older (≥ 65) individuals were observed for wrist/hand pain (25–44: 11.3%, ≥ 65: 22.5%) and hip pain (25–44: 5.6%, ≥ 65: 21.2%) [42], but these large differences were only observed in females. In Norway, the largest differences between younger and older individuals were observed for head pain (< 30: 54.2%, ≥ 60: 24.7%) and knee pain (< 30: 13.3%, ≥ 60: 29.3%) among nursing assistants [36]. In our study, ankle/foot pain was more common in younger (18–29: 42.71%) than in older (≥ 60: 36.08%) pilgrims, whereas low back pain was more common in pilgrims aged over 60 years. These results differ from those of a study conducted in the Netherlands, which found a slight decrease in lower back pain with increasing age [42].

Musculoskeletal pain of the spine

In our study, the most common musculoskeletal pain of the spine among pilgrims was low back pain (28.40%). This result is similar to those of several studies that reported similar low back pain prevalences, such as among agricultural farmers in Nepal (36.18%) [40], dentists in Iran (33%) [38], the general population in the Netherlands (26.9%) [42], construction workers in Saudi Arabia (24.24%) [43] and the general population in Sweden (22.97%) [46]. However, the prevalence of low back pain in our study was slightly lower than that reported in other studies, which reported higher rates of low back pain in school teachers in Saudi Arabia (66.87%) [51], occupational drivers in Nigeria (64.78%) [34], physiotherapists in India (61.50%) [37], nursing assistants in Norway (54.9%) [36], the working population in New Zealand (54%) [35] and dentists in Greece (46.05%) [39].

In terms of potential risk factors, we found that low back pain among pilgrims was more common in females, older (≥ 60) and obese (BMI: ≥30) pilgrims, pilgrims who smoked, those who had diabetes (close to the margin of significance) and hypertension, those who believed that the Hajj is physically exhausting and those who received treatment during the Hajj. These findings are similar to those of several studies that found females were at a higher risk for low back pain than males among the general populations in the United Kingdom [52], the Netherlands [42] and Sweden [46]. However, our findings differ from those of studies reporting that low back pain was more common in males than females among the working population in New Zealand [35]. Furthermore, our findings are similar to those of studies that found an association between the presence of chronic disease [51], anxiety [44, 51] and depression [44, 51] and low back pain. In contrast, other studies also reported no significant association between low back pain and sex [36, 39, 44, 53], age [36, 39, 44, 51, 53], BMI [51, 53] and smoking [39, 44, 53], although some of these studies found significant differences in neck pain based on sex [36, 39, 44], age [39, 44] and smoking status [44]. We found a higher risk of falls among pilgrims who suffered from pain at several spinal sites, including head, neck and thoracic pain. This is in contrast to the older population in the United States, among whom there was no significant association between falls and back pain [45].

Musculoskeletal pain of the upper limb

In our study, the most common form of musculoskeletal pain of the upper limb among pilgrims was shoulder pain (16.09%). This result is similar to those of several studies reporting similar shoulder pain prevalences, such as in the general population in the Netherlands (20.9%), the general population in Sweden (19.88%) [46] and dentists in Greece (19.77%) [39]. However, our results differ from those examining different populations, which reported either higher or lower prevalence rates compared to our study, such as school teachers in Saudi Arabia (59.26%) [51], nursing assistants in Norway (47.1%) [36], the working population in New Zealand (42%) [35], occupational drivers in Nigeria (30.82%) [34], agricultural farmers in Nepal (10.57%) [40], the general population in the United Kingdom (7.48%) [52] and construction workers in Saudi Arabia (4.24%) [43].

In terms of potential risk factors, we found that shoulder pain among pilgrims was more common in females, pilgrims who were underweight (BMI: <18.5) (close to the margin of significance), those who had diabetes and hypertension, those who believed that the Hajj is physically exhausting, those who had experienced a fall during the Hajj and those who received treatment during the Hajj. These findings are similar to those of several studies that found that shoulder pain was more common in females among the general populations in Sweden [46], the United Kingdom [52] and the Netherlands [42], nursing assistants in Norway [36] and the working population in New Zealand [35]. Our findings are also similar to those indicating the presence of chronic disease, anxiety and depression [51] among female school teachers. However, our findings differ from those of a study reporting that shoulder pain was not associated with sex [39] among dentists in Greece. In our study, age was not associated with shoulder pain among pilgrims. This result is similar to those of some studies conducted among dentists in Greece [39] and the general population in the Netherlands [42]. In contrast, some studies found that age was associated with shoulder pain among the general population in the United Kingdom [52] and nursing assistants in Norway [36], where older individuals were at a higher risk than younger individuals. In our study, the prevalence of falls was associated with shoulder pain. This differs from the results of a study conducted among the older population in the United States, which found no association between falls and shoulder pain [45].

Musculoskeletal pain of the lower limb

In our study, the most common location of musculoskeletal pain in the lower limbs among pilgrims was ankle/foot pain (39.07%), which was higher than the prevalence identified in most studies in the literature. Few studies reported higher rates of ankle/foot pain, such as a study conducted among school teachers in Saudi Arabia (ankle: 42.59%, heel: 55.97%) [51]. Most studies reported lower rates of ankle/foot pain compared to our study, such as a study of the working population in New Zealand (20%) [35], nursing assistants in Norway (15.5%) [36], agricultural farmers in Nepal (13.01%) [40], the general population in Sweden (12.37%), occupational drivers in Nigeria (11.95%) [34], the general population in the Netherlands (ankle: 4.9%, foot: 6.5%) [42] and construction workers in Saudi Arabia (3.03%) [43].

In terms of potential risk factors, we found that ankle/foot pain among pilgrims was more common in females, those who had diabetes, those who believed that the Hajj was physically exhausting and those who received treatment during the Hajj. Our results were similar to those of Alfelali et al. (2014), who reported that pilgrims with or without diabetes were at a high risk of developing foot injuries during the Hajj [27], but this study was focused on infectious wounds in the foot. Some studies had similar findings and reported that ankle/foot pain was more common females among the general population in Sweden [46] and in the Netherlands [42]. In our study, although there were significant age-based differences in hip/pelvis, knee and leg pain, there was no difference in ankle/foot pain between younger and older individuals. This result differs from that of some studies reporting that ankle or foot pain was more common in older individuals than in younger individuals among the general population in the Netherlands [42] and nursing assistants in Norway [36].

We did not find an association between BMI and ankle/foot pain. This differs from the results of one study, which reported that heel pain was associated with BMI, although this study did not find similar results for ankle pain [51]. Our findings are also similar to those of studies that found an association between the presence of chronic disease, anxiety and depression [51] among female school teachers and ankle and heel pain. In our study, the prevalence of falls was not associated with higher rates of ankle/foot pain. This is similar to the results of a study conducted among the older population in the United States, which found no association between falls and foot pain [45].

Possible explanations for the differences in the results of musculoskeletal pain between our study and others in the literature

The variations in the results for estimating the prevalence of musculoskeletal pain between our study and others in the literature can be possibly explained by several factors, including the differences in populations, study design and methodology, such as the large variation in the sample size, data collection method and statistical analysis. For example, some studies estimated the point prevalence of musculoskeletal pain [38, 41, 43, 46, 51, 52], whereas others estimated period prevalence [35, 37, 44, 45] or both [40, 42, 49]. Many studies had a small or an average sample size (< 400) [34, 37, 38, 40, 41, 43]. Other studies only estimated the prevalence of chronic cases of musculoskeletal conditions [45–48, 50]. Several studies either limited the data collection to specific regions within the country [38, 43, 44, 46, 52, 53] or to only males [43] or only females [51]. Others included a limited range of age groups (20–29, 30–39, ≥ 40) [51], did not consider participants from the elderly population (< 65) [34, 35, 40, 53] or only included older participants (≥ 70) [45]. This may have influenced the distribution of the data, making it difficult to detect the differences between the younger and elderly populations. Furthermore, some studies did not control for potential confounding variables (e.g., age) [43, 51], which may have led to inaccurate associations. Other studies only focused on particular anatomical sites of pain [52] or included more than one anatomical site of pain as a region, for example, by combining the neck, shoulder and higher back sites into one region [42], by combining all sites of pain for the upper limb or the lower limb [44], combining the hip with the upper leg, combining the lower leg with the foot [46] or combining the hip, thigh and buttock [35]. All of these variations may have impacted the estimation of musculoskeletal pain prevalence.

There are possible explanations for why our study showed a higher prevalence of musculoskeletal pain among pilgrims. One possible explanation is that the Hajj is highly physically demanding; pilgrims move, generally by foot, for long distances, which may exceed the typical physical activity level for most pilgrims and is further complicated by overcrowding, extreme heat and fatigue [11, 13, 15, 21]. Several studies have documented an association between some jobs or tasks with high physical demands and musculoskeletal pain among different populations [37, 46]. For example, individuals who primarily work while standing and for longer periods of time [44, 51], individuals who often or always lift heavy loads [44] and individuals exposed to high physical workloads [35] display an increased risk of musculoskeletal pain, particularly in the lower limb [35, 44]. Other possible explanations are that the normal life routines of individuals may change as they move between places where the geography and climate are different, or individuals may neglect their self-health management while they are preoccupied with religious rituals [11]. Subsequently, pilgrims are at a higher risk for developing musculoskeletal pain.

Study strengths and limitations

To the best of our knowledge, this is the first study that has investigated the prevalence of musculoskeletal pain and associated risk factors among pilgrims. One strength of this study is that the power calculation was performed, and the required sample size was achieved, leading to a large sample with the power to detect significant results where they existed. The data were mainly collected by trusted healthcare professional volunteers who approached individuals at different sites of Mecca during the Hajj. The completion rate of the survey in this study was considerably acceptable (1,715/2,110; 81.28%). Another strength is that all data were collected in a short period (10 days) during the Hajj only to properly estimate the point prevalence of musculoskeletal pain among pilgrims. Another strength is the investigation of the association between musculoskeletal pain and various potential risk factors with the consideration of potential confounding factors by using an adjusted OR ratio that controls for sex and age within the regression model used in this study.

There were some limitations to the current study. First, there was a potential sampling bias due to the use of convenience sampling, which may have produced a sample that is not representative of the entire pilgrim population that visited Mecca to perform the Hajj. However, an attempt was made to reduce the sampling bias by distributing the survey at different sites in Mecca during the Hajj and by collecting data from pilgrims regardless of their nationality. This study also used a cross-sectional design, which is limited to demonstrating a causal association. Another limitation is the fact that 18.72% of the participating pilgrims only provided demographic and major medical history information, without any information related to musculoskeletal pain, which was possibly due to time limitations or a refusal to answer all the follow-up questions; therefore, these responses were excluded from the analysis. Furthermore, due to the way the survey was distributed in this study, and due to the use of convenience sampling, it was impossible to estimate the response rate.

Conclusions

Many healthcare professionals in western countries or counties with a Muslim minority population may not be aware of what the Hajj entails or the associated health risks [11]. As a result, they find it difficult to provide an informed opinion. The findings of this study indicate that musculoskeletal pain is common among pilgrims, and the reported prevalence of musculoskeletal pain is greater among pilgrims than that reported for the general population. This signals a significant public health issue that must be addressed by the Ministry of Health of Saudi Arabia. Unlike most populations, ankle/foot and leg pain were the most common among pilgrims. This is most likely explained by the high walking demands of the Hajj. This study also indicates that sex, age, BMI, smoking, diabetes, hypertension, beliefs about the Hajj, falls and receiving treatment were associated with the prevalence of musculoskeletal pain in various body sites among pilgrims, which should be considered. These data provide guidance for potential preventative programs and the allocation of resources to optimise each individual's experience and capacity to complete the Hajj.

The need to work as a multidisciplinary team and consider an interdisciplinary approach has been emphasised when manging individuals with musculoskeletal pain [54]. According to Taylor et al. (2012), professional musculoskeletal physiotherapists with considerable experience working in emergency departments can be the initial point of contact for individuals with uncomplicated musculoskeletal injuries; this has been found to be valuable and effective in reducing waiting times and length of stay without any negative effects [55]. Therefore, it is recommended for the Saudi Ministry of Health to involve physiotherapists to provide care and educational advice to pilgrims via primary healthcare services, such as the emergency departments, particularly during the Hajj, when the prevalence of musculoskeletal pain is high among pilgrims. In addition to physiotherapist interventions, educational and ergonomic advice and self-management trainings, with a special focus on foot care and hygiene, may have a greater impact on the prevention of musculoskeletal complaints, and it is recommended that these approaches be incorporated into the health services by the Ministry of Health of Saudi Arabia to fulfil all pilgrims' care needs.

Abbreviations

BMI:Body mass index; CI:Confidence interval; OR:Odds ratio

Declarations

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Authors' contributions

MAA and JA conceived the study. MAA, JA, SA, AA, MA and SFA contributed to the data collection. MAA performed the statistical analyses and designed the figures. All authors contributed to the study design and the interpretation of the data and critically and intellectually revised multiple draft versions of the manuscript. MAA and HA drafted the manuscript. All authors read and have given approval for the final version of the manuscript to be published.

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Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

Ethical approval (Reference: FAMS5082018) was received from the Physiotherapy Research Committee of the Faculty of Applied Medical Sciences at Umm Al-Qura University in Mecca, Saudi Arabia. All included participants read the informed consent form and agreed to participate and disclose their health information for research purposes.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1 Demographics and major medical history of the participants

Variables		Male	Female	Total
		N=920 (53.64%)	N=795 (46.36%)	N=1715 (100%)
		N (%)	N (%)	N (%)
Age (years)	18–29	307 (52.03)	283 (47.97)	590 (34.40)
	30–39	250 (58.00)	181 (42.00)	431 (25.13)
	40–49	142 (49.65)	144 (50.35)	286 (16.68)
	50–59	133 (53.20)	117 (46.80)	250 (14.58)
	≥60	88 (55.70)	70 (44.30)	158 (9.21)
BMI (kg/cm^2)	Underweight (<18.5)	45 (62.50)	27 (37.50)	72 (4.20)
	Normal weight (18.5–24.9)	379 (50.60)	370 (49.40)	749 (43.67)
	Overweight (25–29.9)	210 (51.98)	194 (48.02)	404 (23.56)
	Obese (≥30)	286 (58.37)	204 (41.63)	490 (28.57)
Smoker	Yes	316 (83.60)	62 (16.40)	378 (22.04)
	No	604 (45.18)	733 (54.82)	1337 (77.96)
Diabetes	Yes	139 (56.50)	107 (43.50)	246 (14.34)
	No	781 (53.17)	688 (46.83)	1469 (85.66)
Hypertension	Yes	162 (52.09)	149 (47.91)	311 (18.13)
	No	758 (53.99)	646 (46.01)	1404 (81.87)

N number (frequency), *%* percentage, *BMI* body mass index, *kg* kilogram, *cm* centimetre

Table 2 Point prevalence of musculoskeletal pain by anatomical site, sex and age

Pain Location		Age Group					Total	*P*-value
		18–29	30–39	40–49	50–59	≥60		
Head	Male	12.70 (9.43–16.90)	10.40 (7.20–14.80)	11.27 (7.06–17.52)	17.29 (11.81–24.61)	17.05 (10.61–26.24)	12.93 (10.92–15.26)	0.253
	Female	15.55 (11.79–20.23)	24.31 (18.64–31.05)	20.83 (15.00–28.18)	17.95 (12.05–25.89)	11.43 (5.91–20.96)	18.49 (15.95–21.34)	0.073
Cervical	Male	7.17 (4.78–10.61)	12.00 (8.54–16.61)	12.68 (8.17–19.15)	15.79 (10.57–22.93)	20.45 (13.35–30.03)	11.85 (9.92–14.10)	**0.005**
	Female	16.25 (12.41–21.00)	16.02 (11.39–22.06)	14.58 (9.74–21.27)	14.53 (9.27–22.04)	10.00 (4.93–19.23)	15.09 (12.77–17.75)	0.755
Thoracic	Male	13.03 (9.72–17.26)	11.20 (7.86–15.71)	8.45 (4.90–14.19)	14.29 (9.34–21.24)	15.91 (9.72–24.95)	12.28 (10.32–14.56)	0.415
	Female	14.84 (11.17–19.45)	14.36 (10.00–20.22)	9.03 (5.35–14.83)	17.95 (12.05–25.89)	14.29 (7.95–24.34)	14.09 (11.84–16.68)	0.327
Lumbar	Male	18.89 (14.91–23.65)	26.80 (21.69–32.61)	26.06 (19.54–33.84)	29.32 (22.25–37.55)	34.09 (25.04–44.47)	25.11 (22.41–28.01)	**0.019**
	Female	32.86 (27.65–38.53)	30.94 (24.66–38.01)	33.33 (26.16–41.38)	24.79 (17.85–33.33)	42.86 (31.94–54.52)	32.20 (29.05–35.53)	0.143
Shoulder	Male	13.03 (9.72–17.26)	13.60 (9.90–18.40)	8.45 (4.90–14.19)	17.29 (11.81–24.61)	19.32 (12.43–28.78)	13.70 (11.62–16.07)	0.124
	Female	19.08 (14.93–24.06)	18.78 (13.77–25.10)	22.22 (16.20–29.68)	17.09 (11.35–24.93)	14.29 (7.95–24.34)	18.87 (16.30–21.73)	0.687
Upper Arm	Male	2.28 (1.11–4.63)	4.40 (2.47–7.71)	5.63 (2.88–10.72)	3.76 (1.62–8.50)	5.68 (2.45–12.62)	3.91 (2.84–5.37)	0.380
	Female	2.83 (1.44–5.48)	3.31 (1.53–7.04)	2.08 (0.71–5.95)	1.71 (0.47–6.02)	2.86 (0.79–9.83)	2.64 (1.73–4.00)	0.919
Elbow	Male	2.93 (1.55–5.48)	2.40 (1.10–5.14)	1.41 (0.39–4.99)	5.26 (2.57–10.47)	6.82 (3.16–14.09)	3.26 (2.29–4.62)	0.114
	Female	0.71 (0.19–2.54)	2.76 (1.19–6.30)	2.78 (1.09–6.92)	4.27 (1.84–9.62)	1.43 (0.25–7.66)	2.14 (1.34–3.40)	0.191
Forearm	Male	1.95 (0.90–4.20)	2.40 (1.10–5.14)	1.41 (0.39–4.99)	6.77 (3.60–12.36)	4.55 (1.78–11.11)	2.93 (2.02–4.24)	**0.039**
	Female	3.18 (1.68–5.93)	1.66 (0.57–4.76)	2.08 (0.71–5.95)	5.98 (2.93–11.84)	1.43 (0.25–7.66)	2.89 (1.94–4.30)	0.206
Wrist/Hand	Male	4.23 (2.49–7.11)	2.00 (0.86–4.60)	2.11 (0.72–6.03)	8.27 (4.68–14.20)	10.23 (5.47–18.31)	4.46 (3.30–5.99)	**0.002**
	Female	4.24 (2.44–7.26)	3.31 (1.53–7.04)	5.56 (2.84–10.58)	9.40 (5.33–16.05)	1.43 (0.25–7.66)	4.78 (3.50–6.49)	0.077
Hip/Pelvis	Male	1.95 (0.90–4.20)	4.00 (2.19–7.21)	2.11 (0.72–6.03)	6.02 (3.08–11.42)	12.50 (7.13–21.01)	4.13 (3.02–5.62)	**0.000**
	Female	6.36 (4.06–9.83)	3.87 (1.89–7.77)	6.25 (3.32–11.45)	15.38 (9.96–23.01)	11.43 (5.91–20.96)	7.55 (5.91–9.59)	**0.003**
Thigh	Male	11.73 (8.59–15.81)	12.80 (9.21–17.51)	9.15 (5.43–15.03)	12.03 (7.54–18.65)	17.05 (10.61–	12.17 (10.22–	0.506

						26.24)	14.45)	
	Female	21.55 (17.16–26.71)	12.71 (8.62–18.35)	12.50 (8.06–18.89)	11.11 (6.61–18.09)	7.14 (3.09–15.66)	15.09 (12.77–17.75)	**0.003**
Knee	Male	11.73 (8.59–15.81)	17.60 (13.38–22.80)	21.13 (15.22–28.56)	30.83 (23.61–39.12)	44.32 (34.39–54.72)	20.65 (18.16–23.39)	**0.000**
	Female	18.02 (13.98–22.92)	14.92 (10.46–20.83)	29.17 (22.36–37.05)	49.57 (40.67–58.50)	38.57 (28.05–50.28)	25.79 (22.87–28.94)	**0.000**
Leg	Male	24.43 (19.96–29.53)	25.60 (20.59–31.35)	28.87 (22.05–36.81)	24.06 (17.59–31.99)	43.18 (33.33–53.60)	27.17 (24.40–30.14)	**0.008**
	Female	36.04 (30.67–41.79)	27.62 (21.63–34.55)	30.56 (23.62–38.50)	41.03 (32.54–50.09)	38.57 (28.05–50.28)	34.09 (30.88–37.45)	0.100
Ankle/Foot	Male	41.37 (36.00–46.95)	36.80 (31.06–42.94)	35.21 (27.84–43.36)	27.07 (20.24–35.18)	37.50 (28.11–47.94)	36.74 (33.69–39.90)	0.080
	Female	44.17 (38.50–49.99)	43.65 (36.63–50.93)	34.72 (27.43–42.80)	46.15 (37.39–55.17)	34.29 (24.25–45.96)	41.76 (38.38–45.22)	0.171
All	Male	70.68 (65.36–75.50)	78.00 (72.46–82.69)	81.69 (74.52–87.19)	83.46 (76.22–88.82)	86.36 (77.66–92.02)	77.72 (74.92–80.29)	**0.003**
	Female	86.22 (81.72–89.75)	85.08 (79.17–89.54)	88.19 (81.91–92.50)	92.31 (86.03–95.90)	90.00 (80.77–95.07)	87.55 (85.07–89.66)	0.362

The results of point prevalence of musculoskeletal pain with 95% CIs are presented as percentages (%).

Pearson's chi-squared two-tailed test was used to identify significant differences in musculoskeletal pain for each anatomical site between age groups for males and females. The *P*-values of statistically significant ($P<0.05$) associations are printed in bold.

Table 3 Odds ratio for musculoskeletal pain (pain at any anatomical site)

Variables		OR (95% CI)	*P*-value
Sex	Male	1	NA
	Female	2.034 (1.563–2.647)	**0.000**
Age	18–29	1	NA
	30–39	1.245 (0.911–1.703)	0.170
	40–49	1.568 (1.070–2.297)	**0.021**
	50–59	2.016 (1.315–3.089)	**0.001**
	≥60	2.124 (1.261–3.577)	**0.005**
BMI	<18.5	1.047 (0.570–1.926)	0.881
	18.5–24.9	1	NA
	25–29.9	1.055 (0.758–1.467)	0.753
	≥30	1.087 (0.792–1.493)	0.604
Smoker	Yes	2.024 (1.438–2.847)	**0.000**
	No	1	NA
Diabetes	Yes	4.384 (2.381–8.069)	**0.000**
	No	1	NA
Hypertension	Yes	4.250 (2.472–7.308)	**0.000**
	No	1	NA
The belief that the Hajj is physically exhausting	Yes	3.408 (2.528–4.594)	**0.000**
	No	1	NA
Falls	Yes	3.166 (1.839–5.451)	**0.000**
	No	1	NA
Treatment	Yes	4.843 (3.048–7.694)	**0.000**
	No	1	NA

OR odds ratio, *CI* confidence interval, *BMI* body mass index, *NA* not available.

ORs with 95% CIs were calculated as measure of association using multinomial logistic regression (sex was age adjusted, age was sex adjusted, and all others were sex–age adjusted).

Pearson's chi-squared two-tailed test was used to identify significant differences in musculoskeletal pain (pain at any anatomical site) between variables. The *P*-values of statistically significant ($P<0.05$) associations are printed in bold.

Table 4 Odds ratios for musculoskeletal pain of the spine

Variables		Head		Cervical		Thoracic		Lumbar	
		OR (95% CI)	*P*-value	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Sex	Male	1	NA	1	NA	1	NA	1	NA
	Female	1.534 (1.179–1.997)	**0.001**	1.332 (1.007–1.762)	**0.044**	1.181 (0.891–1.565)	0.247	1.429 (1.157–1.766)	**0.001**
Age	18–29	1	NA	1	NA	1	NA	1	NA
	30–39	1.217 (0.860–1.721)	0.268	1.239 (0.853–1.801)	0.261	0.896 (0.620–1.296)	0.560	1.187 (0.897–1.572)	0.230
	40–49	1.160 (0.783–1.718)	0.459	1.204 (0.789–1.837)	0.388	0.591 (0.368–0.947)	**0.029**	1.221 (0.891–1.672)	0.215
	50–59	1.313 (0.879–1.961)	0.183	1.382 (0.900–2.121)	0.139	1.182 (0.784–1.784)	0.424	1.091 (0.780–1.526)	0.609
	≥60	1.058 (0.641–1.745)	0.827	1.460 (0.888–2.400)	0.136	1.116 (0.682–1.829)	0.662	1.811 (1.248–2.627)	**0.002**
BMI	<18.5	0.687 (0.332–1.423)	0.312	0.883 (0.424–1.838)	0.739	1.804 (0.976–3.334)	0.060	0.539 (0.277–1.050)	0.069
	18.5–24.9	1	NA	1	NA	1	NA	1	NA
	25–29.9	0.598 (0.420–0.850)	**0.004**	0.703 (0.486–1.016)	0.061	0.868 (0.588–1.281)	0.476	1.176 (0.891–1.550)	0.252
	≥30	0.573 (0.408–0.804)	**0.001**	0.656 (0.459–0.938)	**0.021**	1.185 (0.836–1.681)	0.340	1.378 (1.059–1.793)	**0.017**
Smoker	Yes	1.476 (1.061–2.053)	**0.021**	1.768 (1.257–2.485)	**0.001**	1.711 (1.216–2.407)	**0.002**	1.450 (1.109–1.894)	**0.007**
	No	1	NA	1	NA	1	NA	1	NA
Diabetes	Yes	1.557 (1.081–2.243)	**0.018**	2.210 (1.535–3.183)	**0.000**	1.120 (0.742–1.691)	0.590	1.348 (0.993–1.831)	0.055[a]
	No	1	NA	1	NA	1	NA	1	NA
Hypertension	Yes	1.343 (0.944–1.910)	0.102	1.644 (1.146–2.360)	**0.007**	1.355 (0.926–1.983)	0.118	1.500 (1.126–1.998)	**0.006**
	No	1	NA	1	NA	1	NA	1	NA
The belief that the Hajj is physically exhausting	Yes	1.595 (1.221–2.082)	**0.001**	1.938 (1.455–2.581)	**0.000**	1.943 (1.455–2.594)	**0.000**	2.310 (1.858–2.871)	**0.000**
	No	1	NA	1	NA	1	NA	1	NA
Falls	Yes	1.503 (1.060–2.131)	**0.022**	1.688 (1.177–2.419)	**0.004**	1.712 (1.189–2.463)	**0.004**	0.920 (0.674–1.256)	0.601
	No	1	NA	1	NA	1	NA	1	NA
Treatment	Yes	1.516 (1.130–	**0.006**	1.938 (1.432–	**0.000**	1.485 (1.084–	**0.014**	1.571 (1.234–	**0.000**

		2.033)		2.623)		2.036)		2.000)	
	No	1	NA	1	NA	1	NA	1	NA

[a]Close to the margin of significance.

OR odds ratio, *CI* confidence interval, *BMI* body mass index, *NA* not available.

ORs with 95% CIs were calculated as a measure of association using multinomial logistic regression (sex was age adjusted, age was sex adjusted, and all others were sex–age adjusted).

Pearson's chi-squared two-tailed test was used to identify significant differences in musculoskeletal pain of the spine between variables. The *P*-values of statistically significant ($P<0.05$) associations are printed in bold.

Table 5 Odds ratios for musculoskeletal pain of the upper limb

Variables		Shoulder		Upper Arm		Elbow		Forearm		Wrist/Hand	
		OR (95% CI)	*P*-value	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Sex	Male	1	NA	1	NA	1	NA	1	NA	1	NA
	Female	1.469 (1.134–1.904)	**0.004**	0.673 (0.389–1.165)	0.157	0.655 (0.358–1.199)	0.170	0.984 (0.558–1.735)	0.955	1.062 (0.674–1.674)	0.794
Age	18–29	1	NA	1	NA	1	NA	1	NA	1	NA
	30–39	1.012 (0.719–1.423)	0.947	1.539 (0.759–3.120)	0.232	1.346 (0.577–3.136)	0.492	0.817 (0.354–1.885)	0.635	0.594 (0.289–1.221)	0.157
	40–49	0.950 (0.643–1.405)	0.799	1.548 (0.701–3.418)	0.279	1.139 (0.417–3.114)	0.799	0.682 (0.246–1.896)	0.464	0.903 (0.438–1.861)	0.782
	50–59	1.102 (0.741–1.638)	0.633	1.099 (0.442–2.731)	0.838	2.644 (1.150–6.080)	**0.022**	2.621 (1.275–5.387)	**0.009**	2.182 (1.206–3.950)	**0.010**
	≥60	1.104 (0.689–1.767)	0.681	1.753 (0.702–4.380)	0.229	2.406 (0.916–6.317)	0.075	1.252 (0.448–3.500)	0.668	1.530 (0.719–3.258)	0.270
BMI	<18.5	1.775 (0.988–3.188)	0.055[a]	3.030 (1.173–7.829)	**0.022**	1.938 (0.639–5.875)	0.242	1.285 (0.373–4.425)	0.691	1.049 (0.360–3.056)	0.930
	18.5–24.9	1	NA	1	NA	1	NA	1	NA	1	NA
	25–29.9	1.008 (0.717–1.418)	0.963	0.547 (0.240–1.244)	0.150	0.596 (0.278–1.275)	0.182	0.487 (0.214–1.108)	0.086	0.529 (0.280–1.000)	**0.050**
	≥30	1.026 (0.738–1.425)	0.879	1.045 (0.554–1.973)	0.891	0.352 (0.154–0.804)	**0.013**	0.601 (0.296–1.223)	0.160	0.582 (0.327–1.036)	0.066
Smoker	Yes	1.337 (0.963–1.855)	0.083	1.946 (1.075–3.523)	**0.028**	1.653 (0.856–3.191)	0.134	1.605 (0.826–3.119)	0.163	1.766 (1.034–3.015)	**0.037**
	No	1	NA	1	NA	1	NA	1	NA	1	NA
Diabetes	Yes	2.137 (1.507–3.030)	**0.000**	3.083 (1.643–5.786)	**0.000**	1.823 (0.898–3.702)	0.097	1.987 (0.995–3.965)	0.052[a]	2.172 (1.249–3.777)	**0.006**
	No	1	NA	1	NA	1	NA	1	NA	1	NA
Hypertension	Yes	2.036 (1.452–2.854)	**0.000**	1.478 (0.747–2.925)	0.262	3.586 (1.819–7.067)	**0.000**	1.218 (0.595–2.491)	0.590	2.190 (1.271–3.772)	**0.005**
	No	1	NA	1	NA	1	NA	1	NA	1	NA
The belief that the Hajj is physically exhausting	Yes	1.808 (1.388–2.354)	**0.000**	0.827 (1.062–1.819)	0.827	0.931 (0.514–1.686)	0.813	0.620 (0.341–1.126)	0.116	1.115 (0.704–1.767)	0.643
	No	1	NA	1	NA	1	NA	1	NA	1	NA
Falls	Yes	1.829 (1.309–2.555)	**0.000**	3.879 (2.181–6.902)	**0.000**	3.918 (2.106–7.289)	**0.000**	1.992 (1.027–3.862)	**0.041**	2.429 (1.448–4.075)	**0.001**
	No	1	NA	1	NA	1	NA	1	NA	1	NA
Treatment	Yes	2.336	**0.000**	2.374	**0.002**	1.963	**0.030**	0.965	0.915	2.518	**0.000**

		(1.764–3.093)		(1.368–4.120)		(1.067–3.611)		(0.499–1.864)		(1.571–4.034)	
	No	1	NA	1	NA	1	NA	1	NA	1	NA

[a]Close to the margin of significance.

OR odds ratio, *CI* confidence interval, *BMI* body mass index, *NA* not available.

ORs with 95% CIs were calculated as measures of association using multinomial logistic regression (sex was age adjusted, age was sex adjusted, and all others were sex–age adjusted).

Pearson's chi-squared two-tailed test was used to identify significant differences in musculoskeletal pain of the upper limb between variables. The *P*-value of statistically significant ($P<0.05$) associations are printed in bold.

Table 6 Odds ratios for musculoskeletal pain of the lower limb

Variables		Hip/Pelvis		Thigh		Knee		Leg		Ankle/Foot	
		OR (95% CI)	*P*-value	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Sex	Male	1	NA	1	NA	1	NA	1	NA	1	NA
	Female	1.932 (1.267–2.947)	**0.002**	1.282 (0.971–1.693)	0.080	1.357 (1.075–1.713)	**0.010**	1.386 (1.126–1.706)	**0.002**	1.239 (1.019–1.506)	**0.032**
Age	18–29	1	NA	1	NA	1	NA	1	NA	1	NA
	30–39	1.007 (0.533–1.902)	0.982	0.754 (0.527–1.079)	0.122	1.162 (0.825–1.636)	0.390	0.855 (0.647–1.129)	0.270	0.893 (0.693–1.151)	0.382
	40–49	1.017 (0.500–2.068)	0.962	0.614 (0.398–0.945)	**0.027**	1.936 (1.362–2.751)	**0.000**	0.979 (0.718–1.334)	0.893	0.717 (0.535–0.961)	**0.026**
	50–59	2.777 (1.558–4.950)	**0.001**	0.668 (0.429–1.042)	0.076	3.826 (2.719–5.384)	**0.000**	1.103 (0.801–1.518)	0.548	0.756 (0.557–1.026)	0.073
	≥60	3.331 (1.769–6.272)	**0.000**	0.743 (0.443–1.247)	0.260	4.221 (2.855–6.240)	**0.000**	1.655 (1.151–2.382)	**0.007**	0.762 (0.530–1.097)	0.144
BMI	<18.5	1.836 (0.735–4.584)	0.193	1.197 (0.632–2.268)	0.581	1.055 (0.554–2.012)	0.870	0.755 (0.427–1.338)	0.336	0.921 (0.559–1.519)	0.748
	18.5–24.9	1	NA	1	NA	1	NA	1	NA	1	NA
	25–29.9	0.777 (0.443–1.361)	0.377	0.766 (0.525–1.118)	0.167	0.929 (0.680–1.269)	0.643	1.091 (0.833–1.431)	0.526	0.865 (0.669–1.120)	0.271
	≥30	0.828 (0.492–1.393)	0.477	0.899 (0.632–1.279)	0.554	1.293 (0.972–1.720)	0.077	1.135 (0.875–1.473)	0.340	1.118 (0.876–1.427)	0.369
Smoker	Yes	1.606 (0.953–2.706)	0.075	1.142 (0.799–1.631)	0.466	1.439 (1.074–1.928)	**0.015**	1.034 (0.791–1.352)	0.806	1.268 (0.989–1.624)	0.061
	No	1	NA	1	NA	1	NA	1	NA	1	NA
Diabetes	Yes	1.539 (0.919–2.579)	0.101	0.639 (0.394–1.038)	0.070	1.789 (1.315–2.435)	**0.000**	1.055 (0.775–1.434)	0.735	1.604 (1.199–2.147)	**0.001**
	No	1	NA	1	NA	1	NA	1	NA	1	NA
Hypertension	Yes	1.688 (1.032–2.761)	**0.037**	0.948 (0.629–1.429)	0.798	1.650 (1.233–2.208)	**0.001**	1.183 (0.889–1.574)	0.249	1.301 (0.988–1.714)	0.061
	No	1	NA	1	NA	1	NA	1	NA	1	**NA**
The belief that the Hajj is physically exhausting	Yes	0.998 (0.657–1.518)	0.993	1.691 (1.274–2.244)	**0.000**	2.124 (1.674–2.694)	**0.000**	1.817 (1.471–2.244)	**0.000**	1.573 (1.289–1.919)	**0.000**
	No	1	NA	1	NA	1	NA	1	NA	1	NA
Falls	Yes	2.379 (1.487–3.805)	**0.000**	1.307 (0.890–1.920)	0.172	1.276 (0.930–1.753)	0.131	1.105 (0.820–1.487)	0.512	1.278 (0.964–1.694)	0.088
	No	1	NA	1	NA	1	NA	1	NA	1	NA
Treatment	Yes	1.441	0.108	1.169	0.347	1.937	**0.000**	1.208	0.126	1.380	**0.006**

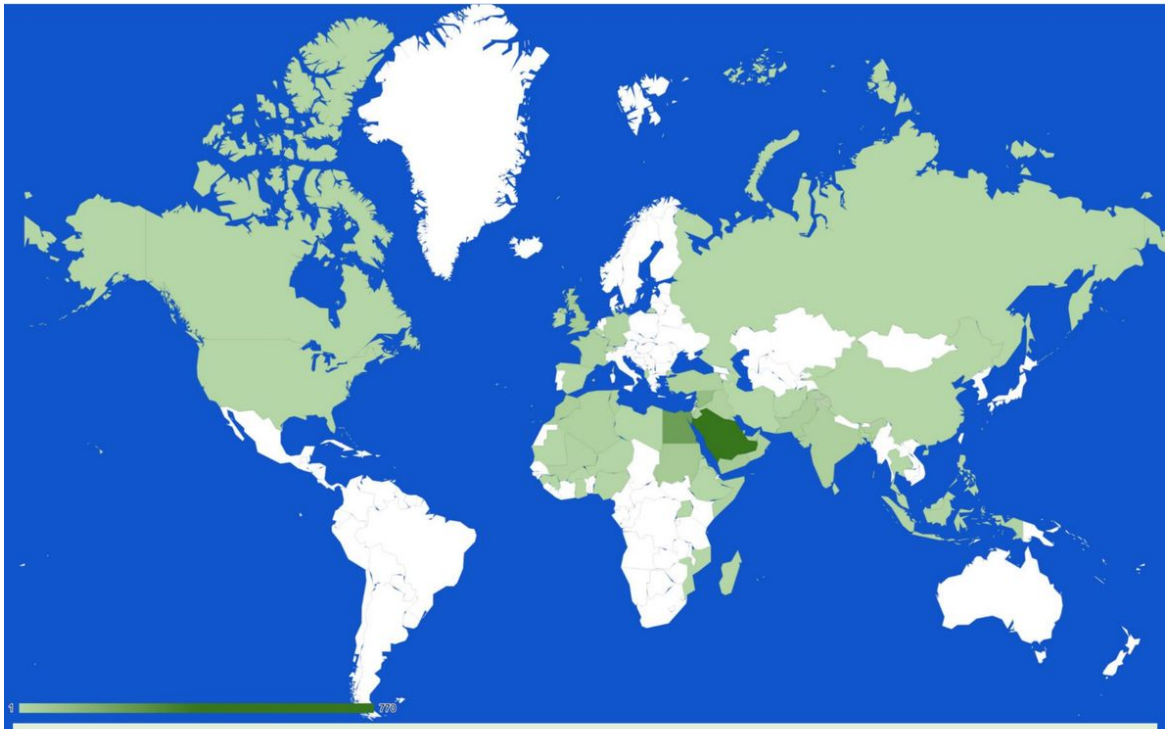
		(0.923–2.251)		(0.844–1.618)		(1.501–2.499)		(0.949–1.537)		(1.097–1.736)	
	No	1	NA	1	NA	1	NA	1	NA	1	NA

OR odds ratio, *CI* confidence interval, *BMI* body mass index, *NA* not available.

ORs with 95% CIs were calculated as measures of association using multinomial logistic regression (sex was age adjusted, age was sex adjusted, and all others were sex–age adjusted).

Pearson's chi-squared two-tailed test was used to identify significant differences in musculoskeletal pain of the lower limb between variables. The *P*-value of statistically significant (*P*<0.05) associations are printed in bold.

Figures



Country	N	%	Country	N	%	Country	N	%
Afghanistan	5	(0.29)	India	29	(1.69)	Pakistan	34	(1.98)
Albania	1	(0.06)	Indonesia	10	(0.58)	Philippines	4	(0.23)
Algeria	22	(1.28)	Iran	1	(0.06)	Qatar	3	(0.17)
Azerbaijan	1	(0.06)	Iraq	20	(1.17)	Russia	1	(0.06)
Anguilla	1	(0.06)	Ireland	1	(0.06)	Saudi Arabia	770	(44.9)
Bahamas	1	(0.06)	Palestine	22	(1.28)	Somalia	16	(0.93)
Bahrain	9	(0.52)	Jordan	22	(1.28)	Spain	3	(0.17)
Bangladesh	3	(0.17)	Kuwait	23	(1.34)	Sri Lanka	1	(0.06)
Belgium	2	(0.11)	Kyrgyzstan	1	(0.06)	Sudan	50	(2.92)
Burkina Faso	1	(0.06)	Lebanon	5	(0.29)	Switzerland	1	(0.06)
Canada	3	(0.17)	Libya	3	(0.17)	Syria	98	(5.71)
China	3	(0.17)	Madagascar	3	(0.17)	Thailand	2	(0.11)
Comoros	2	(0.11)	Malaysia	3	(0.17)	Tunisia	20	(1.17)
Eritrea	1	(0.06)	Mali	16	(0.93)	Turkey	19	(1.11)
Ethiopia	5	(0.29)	Mauritania	4	(0.23)	Uganda	1	(0.06)
Egypt	223	(13.0)	Morocco	33	(1.92)	United Arab Emirates	35	(2.04)
France	21	(1.22)	Mozambique	1	(0.06)	United Kingdom	48	(2.80)
Germany	12	(0.70)	Niger	8	(0.47)	United States	3	(0.17)
Ghana	5	(0.29)	Nigeria	6	(0.35)	Yemen	44	(2.57)
Guinea	1	(0.06)	Oman	29	(1.69)	**All**	**1715**	**(100)**

Figure 1

The nationalities/countries of participating pilgrims. This figure shows the frequency and percentage for each country that the included participants were from. N refers to number and % refers to the percentage.

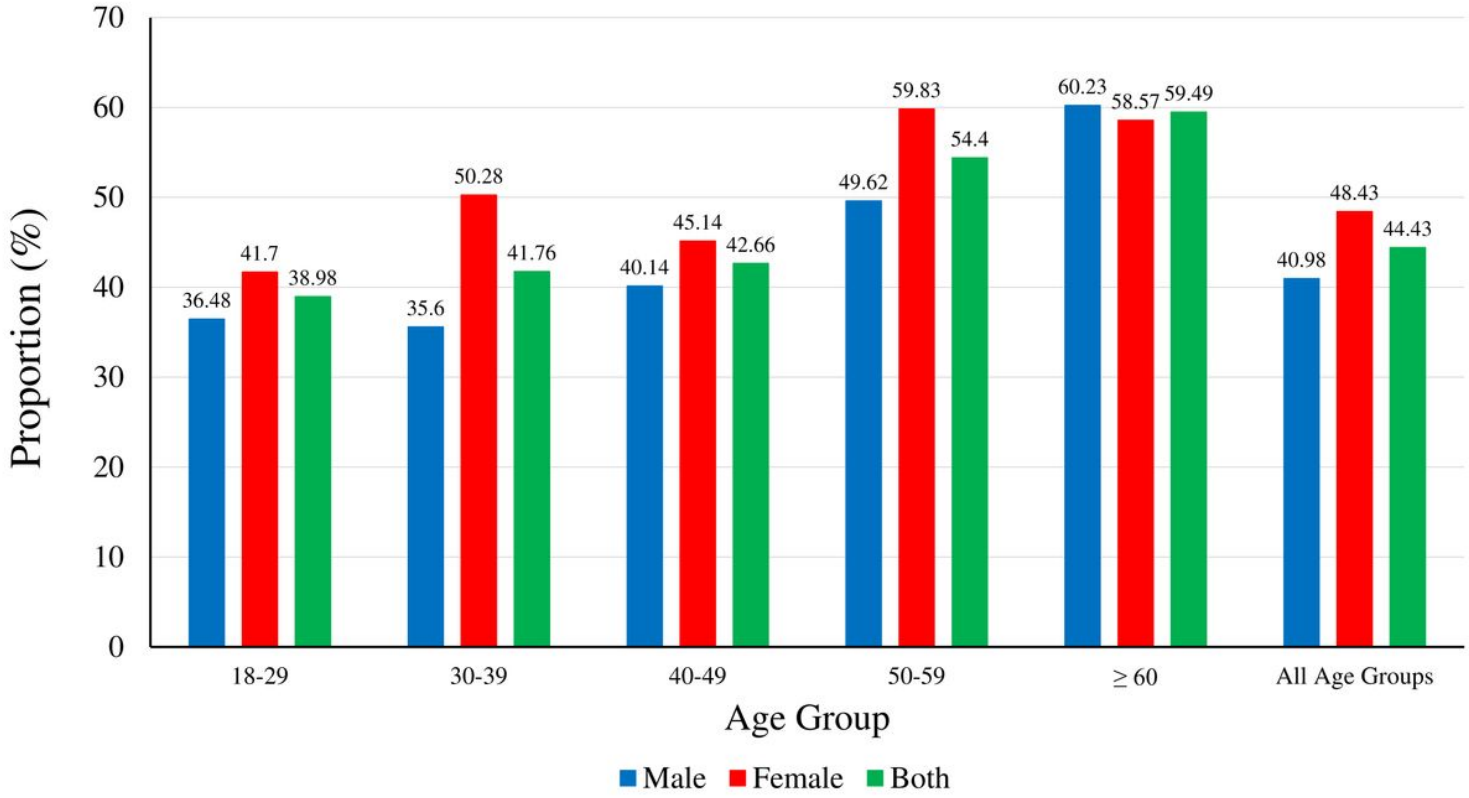
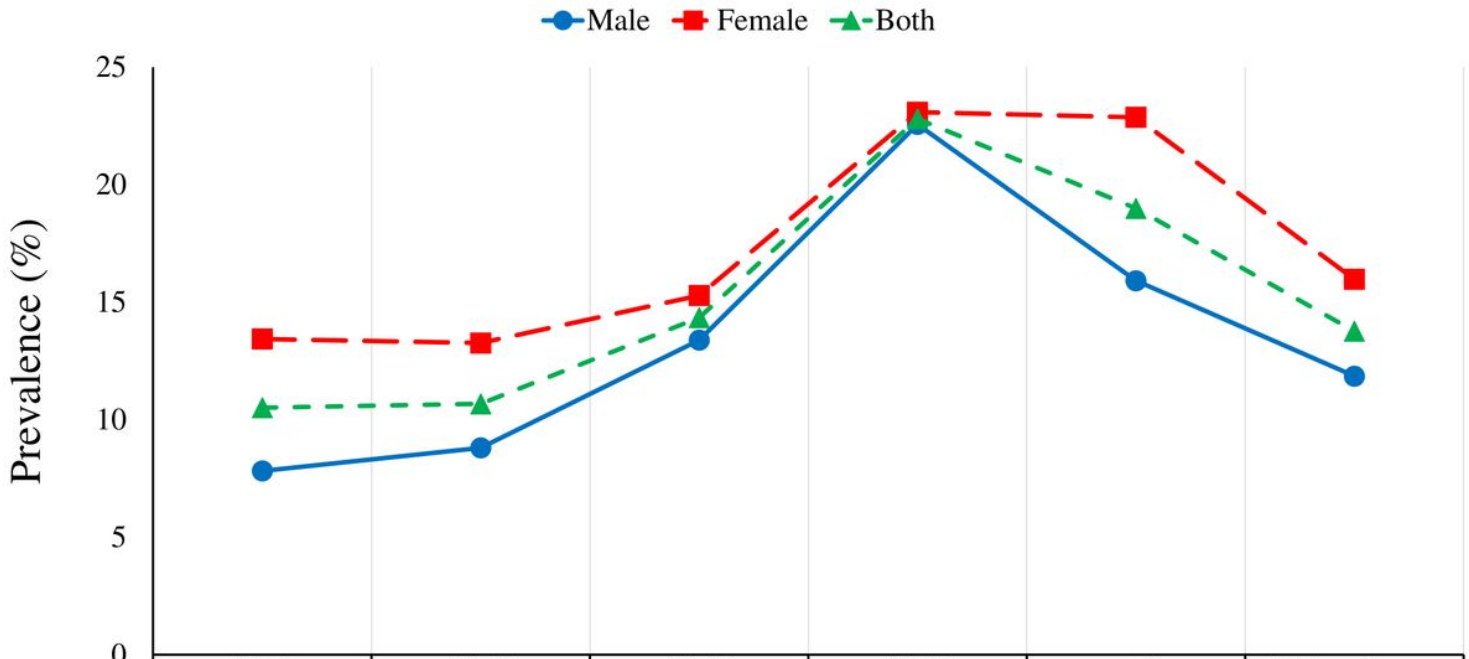


Figure 2

Pilgrims' beliefs about the Hajj. This figure shows the proportion of pilgrims' beliefs about whether the Hajj is physically exhausting. The results are presented by sex and age as percentages.



	18-29	30-39	40-49	50-59	≥ 60	All Age Groups
Male	7.82	8.8	13.38	22.56	15.91	11.85
Female	13.43	13.26	15.28	23.08	22.86	15.97
Both	10.51	10.67	14.34	22.8	18.99	13.76

Figure 3

The prevalence of falls. This figure shows the point prevalence of falls among pilgrims. The results are presented by sex and age as percentages.

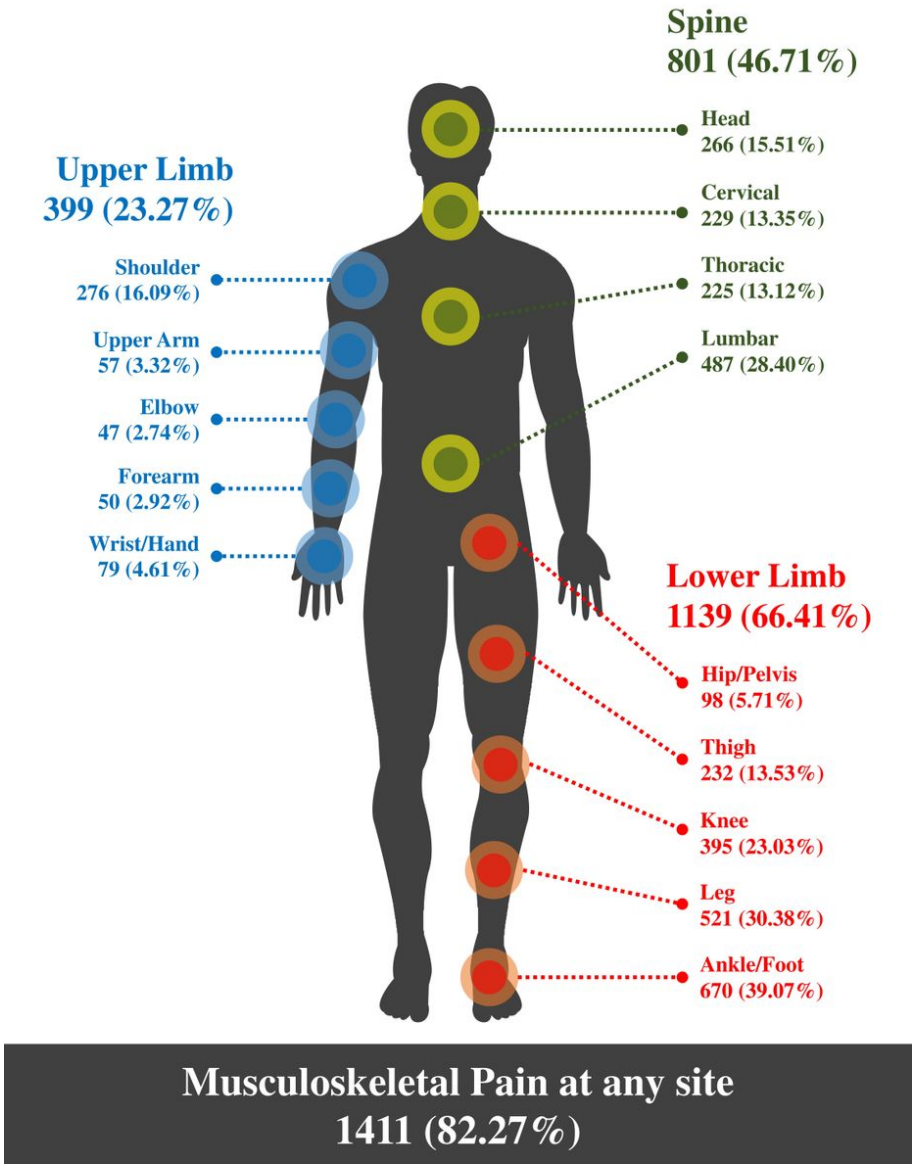
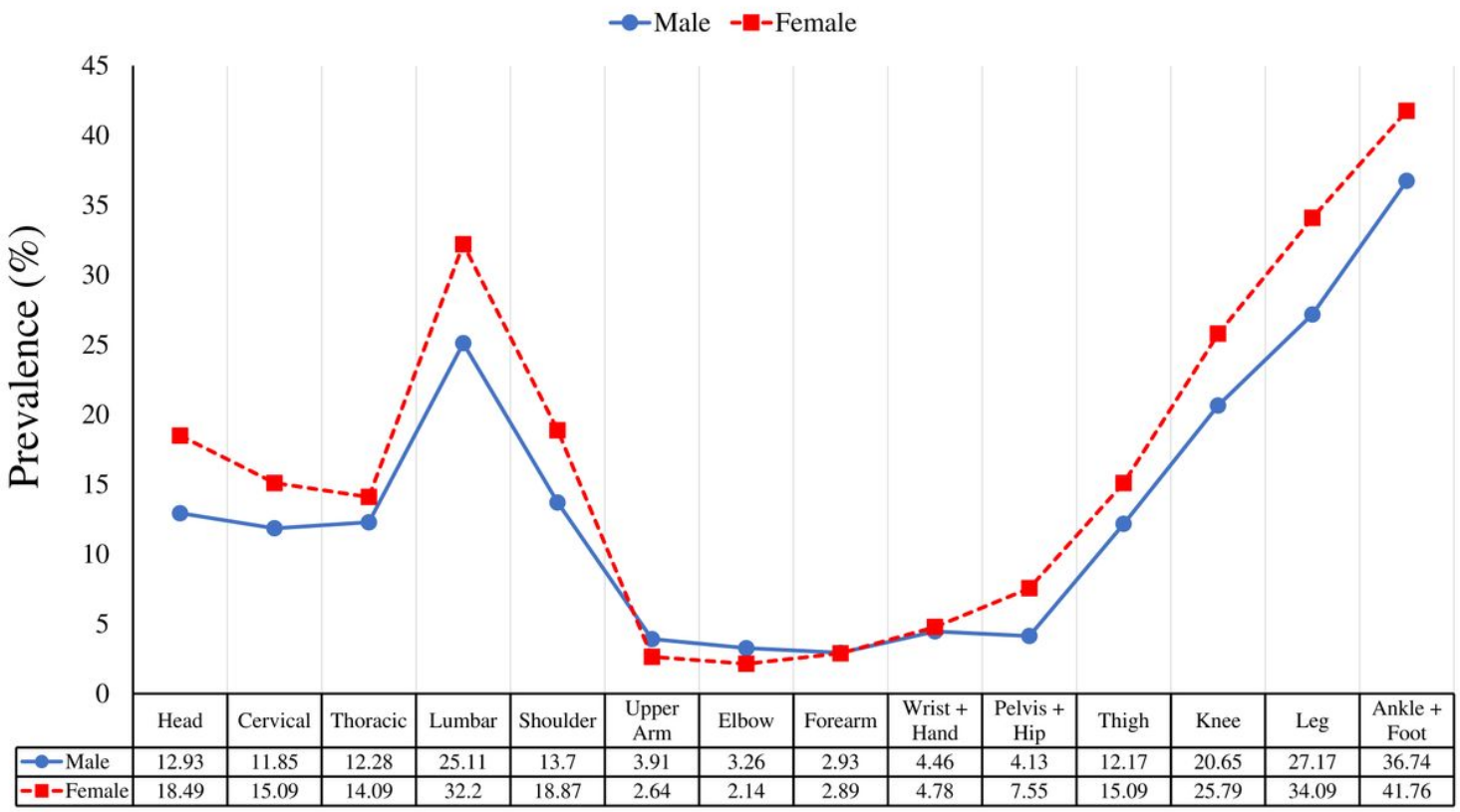


Figure 4

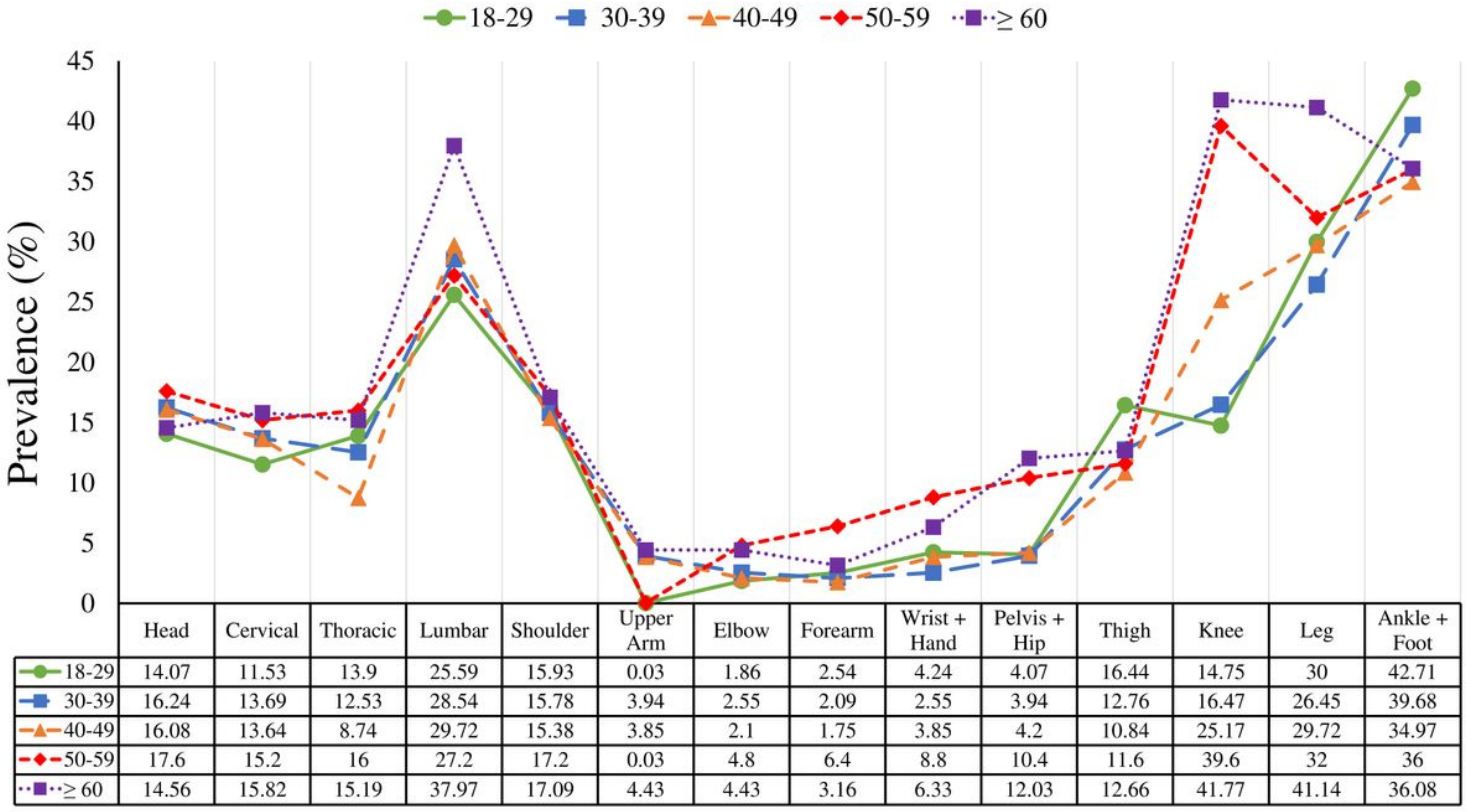
The prevalence of musculoskeletal pain by anatomical site. This figure shows the point prevalence of musculoskeletal pain among pilgrims. The results are presented as frequencies and percentages for each anatomical site.



	Head	Cervical	Thoracic	Lumbar	Shoulder	Upper Arm	Elbow	Forearm	Wrist + Hand	Pelvis + Hip	Thigh	Knee	Leg	Ankle + Foot
Male	12.93	11.85	12.28	25.11	13.7	3.91	3.26	2.93	4.46	4.13	12.17	20.65	27.17	36.74
Female	18.49	15.09	14.09	32.2	18.87	2.64	2.14	2.89	4.78	7.55	15.09	25.79	34.09	41.76

Figure 5

The prevalence of musculoskeletal pain by anatomical site and sex. This figure shows the point prevalence of musculoskeletal pain among pilgrims by anatomical site and sex. The results are presented as percentages for each anatomical site and sex.



	Head	Cervical	Thoracic	Lumbar	Shoulder	Upper Arm	Elbow	Forearm	Wrist + Hand	Pelvis + Hip	Thigh	Knee	Leg	Ankle + Foot
18-29	14.07	11.53	13.9	25.59	15.93	0.03	1.86	2.54	4.24	4.07	16.44	14.75	30	42.71
30-39	16.24	13.69	12.53	28.54	15.78	3.94	2.55	2.09	2.55	3.94	12.76	16.47	26.45	39.68
40-49	16.08	13.64	8.74	29.72	15.38	3.85	2.1	1.75	3.85	4.2	10.84	25.17	29.72	34.97
50-59	17.6	15.2	16	27.2	17.2	0.03	4.8	6.4	8.8	10.4	11.6	39.6	32	36
≥ 60	14.56	15.82	15.19	37.97	17.09	4.43	4.43	3.16	6.33	12.03	12.66	41.77	41.14	36.08

Figure 6

The prevalence of musculoskeletal pain by anatomical site and age. This figure shows the point prevalence of musculoskeletal pain among pilgrims. The results are presented as percentages for each anatomical site and age.

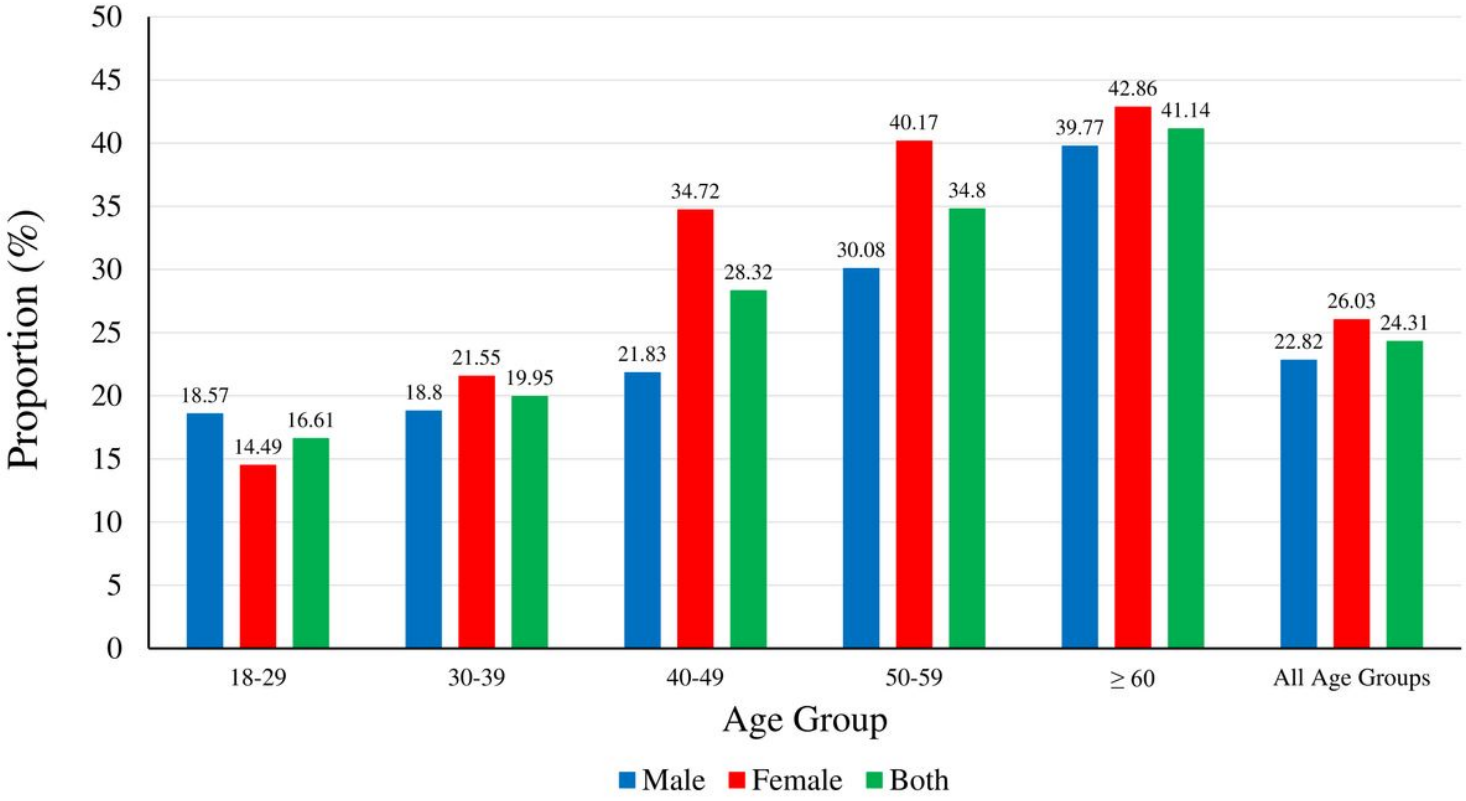


Figure 7

Seeking treatment during the Hajj. This figure shows the proportion of pilgrims who received medical treatment due to musculoskeletal pain they felt during the Hajj. The results are presented by sex and age as percentages.