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3 **Association of musculoskeletal discomfort with the use of high**
4 **heeled shoes in females**

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9
10 **Abstract**

11 **Objective:** To determine the association of musculoskeletal discomfort with the
12 high heeled shoes related variables in females who use such footwear
13 frequently.

14 **Methods:** A cross sectional study was conducted on 174 female residents of
15 Islamabad and Rawalpindi, for a time period stretching from July 1, 2018 to
16 December 31, 2018. The participants aged between 18 and 55 years appeared as
17 the frequent users of high heeled shoes. The Nordic Musculoskeletal
18 Questionnaire (NMQ) and Numeric Pain Rating Scale (NPRS) were used as
19 outcome measures to assess the musculoskeletal discomfort and a self-
20 structured questionnaire was used to obtain information related to the high
21 heeled shoes e.g. duration and frequency of high heeled shoe use. Data was
22 analyzed using SPSS version 21.

23 **Results:** The data analysis showed a positive association of shoulders'
24 discomfort with length of high heeled shoes used by women (p value=
25 0.03<0.05). Moreover, a positive association was also found between an
26 occurrence of upper back discomfort and length of the heeled shoes (p value=
27 0.01<0.05). However, no significant association was found between pain

28 intensity and length of the shoe' heel, frequency and duration of high heeled
29 shoe use.

30 **Conclusion:** The shoulders' and upper back discomfort in females who
31 frequently used high heeled shoes was determined to be associated with the
32 length of the heels in shoes.

33 **Keywords:** Female, Heel, Musculoskeletal System, Pain, Shoes

34

35 **Introduction**

36 Most women consider high-heeled shoes (HHS) as a fashion symbol.⁽¹⁾ The use
37 of this specific footwear is deemed as characteristic of beauty, self-assurance
38 and elegance.⁽²⁾ It has been seen that 1 in 10 women wear it for at least three
39 days a week, and a recent survey found that one-third of them had permanent
40 problems.⁽³⁾

41 Many working women select footwear based on aesthetic appearance which
42 influences the footwear design, however comfort and practicality are not
43 necessarily considered as high a priority, thus adverse pathologies become
44 increasingly apparent during prolonged wear.⁽⁴⁾

45 Therefore, it is important to investigate and understand the effects that shoes of
46 high heel heights have on the musculoskeletal system.

47 For more than 50 years, concerns regarding the potential impact of HHS on
48 women's health have been expressed in medical circles. Qualitatively consistent
49 alterations to the neuromechanics of walking (gait) and effect on the kinematics
50 and kinetics of bodily structures from the toes to the spine have been seen
51 because of using HHS.⁽⁵⁾

52 The frequent and prolonged use of HHS has a direct impact on the spine.
53 Excessive spinal extensor muscles activation, which contributes to the
54 compression of the spine, might be caused by shock and ground reaction forces
55 which leads to excessive axial pressure onto the intervertebral discs.⁽⁶⁾ Thus,
56 wearing HHS for a prolonged time period can result in an increase in paraspinal

57 musculature activation of lumbar and cervical spine, causing long term overload
58 and fatigue in trunk and neck muscles.⁽⁶⁾ Clinically, muscle overuse could be
59 exacerbated by increased lumbar erector spinae muscle activity associated with
60 wearing high heeled shoes and may lead to low back problems.^(7, 8) High heeled
61 shoes users exhibit significantly lower maximum and minimal lumbar and
62 thoracic curvature angles as compared to the barefoot condition. Therefore, low
63 back pain might be associated with other factors caused by high heels.⁽⁹⁾
64 Furthermore, at pre-swing and swing phases of gait, there is a 23% increase in
65 hip flexor work in response to a higher hip extension moment in high-heeled
66 gait, thereby disturbing the normal musculoskeletal action at hip.⁽¹⁰⁾
67 HHS also contributes to the musculoskeletal changes around knee joint. The
68 higher knee extensor moments and knee flexion angles induced can cause an
69 increased risk of developing patellofemoral pain and knee osteoarthritis, by
70 increasing joint reaction force.⁽¹¹⁾
71 As compared to a no heel inclination, the time taken for the knee to reach
72 maximum flexion in gait while wearing HHS is recorded to be longer. ⁽¹⁰⁾
73 The mechanism for knee unlocking that enables knee flexion might also be
74 disturbed because of such footwear. Therefore the discussion suggested that the
75 knee would be more susceptible to injury when high heels are in frequent use.⁽¹⁰⁾
76 Moreover, contractile properties of soleus muscle might also be affected, even
77 more than the gastrocnemius muscle, due to habitual use of HHS.⁽¹²⁾
78 Accordingly, it is reasonable to expect that habitual users of such footwear
79 would be more prone to anterior cruciate ligament injury with physically
80 demanding activities, and they would require extra effort for rehabilitation in
81 case of injury.⁽¹²⁾
82 Additionally, the contact pressure at all metatarsophalangeal joints increases
83 and reaches its maximum at push off phase during locomotion, meanwhile the
84 first metatarsophalangeal joint has the largest magnitude. The first and fifth
85 metatarsophalangeal joints have larger movements in transverse plane among all

86 joints, indicating that these two joints bend more significantly by toe box
87 restraint during locomotion.⁽¹³⁾

88 Furthermore, an individual's likelihood of experiencing a lateral ankle sprain is
89 thought to increase by wearing HHS. It might also increase due to the flexed
90 and inverted posture of the plantar aspect of the foot while wearing such
91 footwear. HHS might also cause foot and heel pain because there is a definitive
92 change in subtalar joint axis while walking on HHS in comparison to normal
93 shoes.⁽³⁾

94 HHS could also cause musculoskeletal diseases in the foot and ankle, such as
95 plantar fasciitis⁽¹⁰⁾, hallux valgus, ankle sprain among many others.⁽¹⁴⁾

96 Though studies have been conducted on HHS previously including the
97 prevalence of musculoskeletal pain among young females who wear such
98 footwear,⁽¹⁵⁾. However, no research study has yet been conducted in Pakistan to
99 determine the association of HHS related variables (such as heel length,
100 duration, and frequency of HHS use) with the musculoskeletal discomfort in
101 females who use such footwear frequently. It is important to determine this
102 association because of the harmful effects of such footwear on the
103 musculoskeletal system, including shoulders and upper back regions.

104 The aim of this study was to determine the association of musculoskeletal
105 discomfort with the high heeled shoes related variables in females who use such
106 footwear frequently.

107

108 **Subjects and Methods**

109 A cross sectional survey was conducted from July 2018 to December 2018 on
110 the females residing in the twin cities of Pakistan i.e. Rawalpindi and
111 Islamabad. After approval from the ethical committee, informed consent from
112 the participants and assurance concerning the confidentiality of their data, a
113 total of 174 females fulfilling the eligibility criteria were recruited from the
114 public places of the twin cities including recreational parks, outside the malls,

115 mega marts, supermarkets, tourist attractions, and bus stops. The study sample
116 was selected through non probability convenient sampling and the sample size
117 was calculated through Rao Soft on-line software, with confidence interval 95
118 per cent, margin of error 5 per cent, and the population size 3,613,802
119 (Rawalpindi's female population= 2,663,075 plus Islamabad's female
120 population= 950,727).⁽¹⁶⁾⁽¹⁷⁾ Resultantly the sample size came out to be 385
121 females, which we approached to obtain the data from. However, only 174 out
122 of these 385 females were frequent users of high heeled shoes and fulfilled the
123 inclusion criteria of this study.

124 Females of age between 18 and 55 years who were users of at least 2.5 inches
125 long heels for at least 4 times a week, and for at least 4 hours per day were
126 included while females who had a previous history of musculoskeletal injury
127 which was less than a month old, history of structural deformity or bone
128 diseases, amputations or diagnosed musculoskeletal disorders, or those females
129 who had diagnosed neurological or cognitive impairment were excluded from
130 the study.

131 The Nordic Musculoskeletal Questionnaire (NMQ) and Numeric Pain Rating
132 Scale (NPRS) were used as outcome measures to assess the musculoskeletal
133 discomfort and a self-structured questionnaire was used to obtain information
134 related to the high heeled shoes. All the questions were asked in English
135 language as all the participating females had at least completed the Higher
136 Secondary School Certificate from English medium schools and so they
137 understood the English language well.

138 NPRS is an 11-point scale, which intends to determine the subjective intensity
139 of pain in which '0' means no pain while '10' means the highest pain
140 imaginable. The patient selects a value consistent with their pain intensity in the
141 last 24 hours.⁽¹⁸⁾ It is a valid and reliable tool with good sensitivity.⁽¹⁹⁾ NMQ is a
142 valid tool for analysis of musculoskeletal symptoms.⁽²⁰⁾ It has been previously
143 used in English language for participants who can comprehend the language

144 well. ⁽²¹⁾ It consisted of two sections. Section 1 consisted of 40 forced-choice
145 items identifying areas of the body causing musculoskeletal problems.
146 Completion is aided by a body map to indicate nine symptom sites identified as
147 neck, shoulders, upper back, elbows, low back, wrist/hands, hips/thighs, knees
148 and ankles/feet. Section 2 consisted of additional questions relating to the neck,
149 shoulders and the lower back with further details on relevant issues. Twenty-
150 five forced-choice questions elicited any accident affecting each area, functional
151 impact at home and work (change of job or duties), duration of the problem,
152 assessment by health professional and musculoskeletal problems in the last 7
153 days. Respondents were asked if they have had any musculoskeletal trouble in
154 the last 12 months especially last 7 days which had obstructed normal activity.
155 NMQ is a repeatable, sensitive and useful as a screening and surveillance
156 tool.⁽²²⁾ Data was analyzed using SPSS version 21.

157 The correlation between trouble in different body regions during last twelve
158 months and length of the HHS was analyzed by applying Chi square test. The
159 correlation between length of shoe heel and pain intensity was analyzed using
160 Spearman's correlation test.

161 Descriptive statistics were calculated to find out overall percentage and
162 frequency of HHS use.

163

164 **Results**

165 Total female participants recruited were 174, out of which most (73%) were
166 young adults (19-29 years), 12.1% were middle aged (30-39 years), 10.9% were
167 established adults (40-49 years) and 4% of the participants were seniors (50-55
168 years).⁽²³⁾ Table 1 shows the description of the study sample. The mean age was
169 calculated to be 28.46 ± 8.54 years. The mean height of the participants was
170 155.26 ± 4.77 centimeters and the mean weight was 60.61 ± 12.01 kilograms.

171 The sample consisted of both working and non-working females. (Table 1)

172 Majority, i.e., 67 (38%) of the females used wedge type of heels and most of
173 them, i.e., 70 (40%) used HHS consisting of a leather sole.

174 Moreover, it has also been determined that 110 (63%) women preferred for
175 frequent use a heel length of 3 inches.

176 Furthermore, the results of this study also showed that 110 (63%) females wore
177 HHS for 4 days a week, and 65 (37%) females wore HHS for duration of at least
178 7 hours a day.

179 The pain intensity caused by HHS use was also determined in this study: 33 (19
180 %) females usually felt no pain (0 on NPRS), 59 (34%) participants reported
181 mild pain (a score between 1 and 3 on NPRS), 68 (39%) participants reported
182 moderate pain (a score between 4 and 7 on NPRS), and 14 (8 %) participants
183 reported severe pain (a score between 7 and 10 on NPRS) because of using
184 HHS frequently.

185 Moreover, participants were also asked if there was a better alternative to high
186 heels for frequent use, to which 72 (41%) females responded with a 'no'.

187 Table 2 shows the correlation between trouble in different body regions during
188 last twelve months and heel length, frequency and duration of HHS used by the
189 participants, which was analyzed by applying Chi square test.

190 Furthermore, it was determined that trouble in shoulders and length of high heel
191 is significantly correlated (p value: $0.03 < 0.05$).

192 It was also seen that trouble in upper back and length of high heels is also
193 significantly correlated (P value: $0.01 > 0.05$).

194 Graph 1 shows correlation between length of HHS and pain intensity, which
195 was analyzed using Spearman's correlation test. The correlation between
196 duration of HHS use and pain intensity is also shown in Graph 1.

197

198 **Discussion**

199 In addition to determining the prevalence of lower back and lower limbs'
200 discomfort because of HHS use, the results also showed an association between

201 shoulders' and upper back discomfort with length of the heels used by women.
202 Cowley E. et al explained in their study that this might be because the higher
203 magnitude of vertical ground reaction forces in HHS contributes not only to
204 discomfort but also increases the risk of injury. This, in combination with the
205 loss of lumbar lordosis, also increases the axial compression of intervertebral
206 discs. Furthermore, the effects are significantly increased with the more active
207 erector spinae muscles, which act to compress the spine. ⁽²⁴⁾

208 It has also been determined that majority in this study preferred wearing 3
209 inches long heels most of the time, and over half of them suffered from lower
210 back discomfort. This correlated with the findings of a previous study which
211 showed that fatigue of lumbar muscles was lesser when the heel was 4 cm (1.5
212 inches) high or less. However, a considerable increase in muscle fatigue was
213 shown when the heel was higher than 6 cm(2 inches) and the body muscles
214 tensed to improve body balance, thus causing muscle fatigue and pain in the
215 back, shoulders and neck. ⁽²⁵⁾ Moreover, the levels of muscle activation of
216 cervical, thoracic, and lumbar paraspinal muscles were higher when wearing
217 HHS than when wearing shoes with normal heels.⁽²⁵⁾

218 Furthermore, half of the women who wore 3 inches long heels mostly had
219 discomfort in their knees, as well. This might be because the knee does not
220 achieve same amount of flexion in HHS compared to low-heeled shoes. This
221 related to the findings of a previous study which concluded that compared to
222 barefoot gait during pre-swing phase, a 200 per cent increase in concentric knee
223 extensor activity was observed in HHS. This significant increase in moment of
224 force created by the knee extensor muscles, countered the knee flexion moment
225 of force and therefore reduced the amount of knee flexion during the swing
226 phase in high-heeled gait. ⁽²⁴⁾

227 Furthermore, 79 of the 110 females (71.8%) who frequently wore 3 inches long
228 heels, suffered from discomfort in ankles and feet. Similar results have been
229 reported in a previous study, which suggested that this women who regularly

230 wear HHS are more prone to fatigue of peroneus longus and gastrocnemius
231 lateralis muscles as compared with women who do not wear HHS. ⁽²⁶⁾
232 Furthermore, the eccentricities of the center of pressure under the heel and
233 metatarsal heads are abnormally shifted to the lateral aspect during gait, when
234 fatigued.⁽²⁶⁾ According to another study conducted in the past, the ankle and feet
235 discomfort because of HHS could also be caused by the ankle joint axis moving
236 anteriorly and the line of gravity moving posteriorly toward the ankle joint
237 when wearing HHS. Thus the foot became immediately shorter because of the
238 arch rising. ⁽²⁴⁾.

239 It should however be noted that the use of HHS could be beneficial in treating
240 specific pathologies. Cyriax postulated that heel elevation could decrease
241 plantar fascia strain. Recently, further cadaveric studies and finite element
242 modeling confirmed these findings. According to the latter, a heel height of
243 approximately 2 inches would be beneficial in the treatment of plantar
244 fasciitis. ⁽²⁴⁾

245 It is suggested that high heels be treated as a luxury used on special occasions.
246 Females should limit their use to no more than 3 hours at a time and should not
247 wear them for any prolonged walking. Furthermore, fabric or skin on the upper
248 side of shoe should be chosen that expands, and try to select a shoe that has a
249 rounded or squared toe. Moreover, a shoe with a straight last will reduce the
250 lateral force on the great toe and reduce hallux valgus deformity. ⁽²⁷⁾

251 The limitation of the study was that the sample size was not large enough to
252 make strong generalization. The target population resided in the twin cities of
253 Rawalpindi and Islamabad which again limits its generalizability. There is no
254 joint consensus on the heel height cut off value as yet, ⁽⁵⁾ and the heel height that
255 might cause musculoskeletal discomfort could not be determined in this study.

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259 **Conclusion**

260 The musculoskeletal discomfort in the upper back and shoulders experienced by
261 females who wore HHS frequently has been determined to be associated with
262 heel length of their footwear.

263

264 **Disclaimer:** The manuscript was a part of our research project of Doctor of
265 Physiotherapy program at Shifa Tameer e Millat University, Islamabad.

266 **Conflicts of interest:** None to declare.

267 **Funding disclosure:** None to declare.

268

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343 **Table 1: Description of the Study Sample**

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Variable	Categories	Frequency	Percentage%
Age (years)			
	19-29 (young adults)	127	73
	30-39 (middle aged adults)	21	12.1
	40-45 (established adults)	19	10.9
	50-70 (seniors)	7	4
Marital status			
	Unmarried	105	60.3
	Married	69	39.7
Occupation			
	Employed	108	62.1
	Unemployed	66	37.9

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365 **Table 2: Association between Musculoskeletal Discomfort and Length,**
 366 **Frequency and Duration of High Heel Use.**

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Musculoskeletal Discomfort in body region (trouble during last 12 months)	Variables	P value
Neck Discomfort	Length	0.22
	Frequency	0.89
	Duration	0.81
Shoulder Discomfort	Length	0.03
	Frequency	0.87
	Duration	0.37
Upper Back Discomfort	Length	0.01
	Frequency	0.55
	Duration	0.14
Elbow Discomfort	Length	0.22
	Frequency	0.21
	Duration	0.96
Wrist/Hand Discomfort	Length	0.14
	Frequency	0.79
	Duration	0.54
Lower Back Discomfort	Length	0.95
	Frequency	0.12
	Duration	0.49
Hip Discomfort	Length	0.36
	Frequency	0.08
	Duration	0.14
Knee Discomfort	Length	0.34
	Frequency	0.2
	Duration	0.57
Ankle/Foot	Length	0.14
	Frequency	0.3
	Duration	0.5

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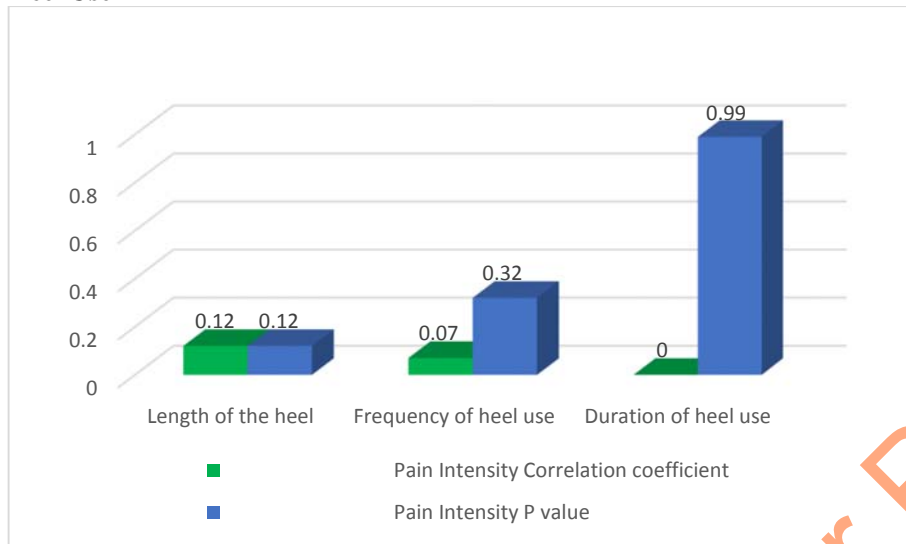
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375 **Graph 1: Correlation between Pain Intensity and Length, Frequency, and Duration of High**
376 **Heel Use**



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