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Effect of High-heeled Shoes and Culturally Habitual Posture on Calf Muscle Flexibility

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ABSTRACT. Objective: The main objective of this study was to evaluate the combined effect of both high-heeled shoes and specific habitual position of the feet and ankle joints on the flexibility of calf muscles. **Design:** Eighty health college female students voluntarily participated in the study. Forty of them were habitual low-heeled shoe wearers (group 1). Their mean age was 21.7±4.2 years, mean weight, 51.4±11.4 kg and mean height was 155±8.8 cm. The remaining forty subjects (group 2) were habitual high-heeled shoe wearers. Their mean age was 20.4±5.1 years, mean weight, 52.7±10.2 kg and mean height was 155±6.7 cm. The index of calf muscle flexibility was the range of motions [dorsiflexion (DF) and plantar flexion (PF)] of the right and left ankle joints as measured with a standard goniometer and flexometer. The measurements taken with both devices were highly correlated ($r = +0.99$). The data were subjected to a one-tailed student t-test statistical analysis with $p < 0.05$ chosen as the level of significance. **Results**: Low-heeled shoe wearers (group 1) have significantly ($p < 0.05$) higher DF measurements (26.6±4.54 degrees for the right; 26.0±4.50 degrees for the left) at the ankle joints than the high-heeled shoe wearers (group 2) (15.4±5.10 degrees for the right and 14.4±4.42 degrees for the left), while there was no significant difference between the two groups in respect of PF measurements (47.8±5.02 degrees for the right ankle and 47.07±5.47degrees for the left in group 1 and 48.05±4.86 degrees for the right ankle and 47.7±4.86 degrees for the left ankle in group 2). **Conclusion**: The conclusion to be made was that there existed some degree of tightness in the calf muscles of group 2 subjects.

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Introduction

The importance of stable and mobile ankle joints cannot be overemphasized in the light of the joints' involvement in highly fundamental activities of daily living such as walking and dynamic weight-bearing. The ankle joint complex is comprised of articulations between the tibia, fibula and talus. The ankle joint is essentially a uniplanar hinge joint allowing dorsiflexion (DF) during which the dorsum of the foot approximates the anterior aspect of the lower leg and plantar flexion (PF), when the sole or plantar aspect of the foot approaches the posterior aspect of the leg. However, it must be noted that there is always the tendency for a combination of inversion at the subtalar joint occurring with PF at the ankle joint. In the same manner, eversion movement at the subtalar joint can also occur with DF of the ankle joint (Kibler *et al.*, 1991; Kitaoka and Lou 1997).

Nowadays, fashion-conscious young adults easily become influenced by dress trends, with little or no consideration of the inimical effects or hazardous implications of such outfits or footwear on their general and physical states of well-being. Young college female adults are especially vulnerable with regards to the fashion of wearing high-heeled shoes without any thought being given to the potentially adverse effects such shoes may have on their physical well being.

It is equally desirable to observe whether the culturally habitual positioning of the ankles, especially during kneel-sitting posture assumed during Islamic mode of prayers, will play any role in the potential change in the flexibility of the principal muscle groups (dorsiflexors and plantar flexors) around the ankle joints.

Materials and Methods

Subjects

Eighty healthy young female college students participated in the study. Forty of them were classified as habitual low-heeled shoe wearers because they did not subscribe to the habit of wearing high-heeled shoes. They belonged to group 1 of the study. Their mean age was 21.7±4.2 years, mean weight was 51.4±11.4kg and mean height was 155.0±8.8 cm.

The group 2 subjects (n = 40) were classified as habitual high-heeled shoe wearers because they wore high-heeled shoes most days of the week. The height of the shoe heels considered as high in this study was 5 cm and above. The mean age of group 2 subjects was 20.4±5.1 years, the mean weight was 52.7±10.2 kg and mean height was 155.0±6.7 cm.

Prior screening of the subjects by the authors (using their expertise in orthopedic physical therapy) ensured that none of the subjects had ankle deformities. The daily program of activities of all the participating subjects compelled them to wear shoes for about one-third of the day.

Measurements of Ankle Range of Motion (Flexibility Index)

For the purpose of this study, other associated motions of subtalar joints were neutralized leaving only the ankle dorsiflexors and plantar flexors as the principal operating muscle groups. The range of motions at the ankle joints was used as an index of flexibility of the principal muscles, DF and PF.

Measurement instruments used were the standard goniometer and flexometer, as these two instruments are clinically acceptable for routine evaluation of the range of motion of joints (Slatyer and Hensley, 1997; Raab *et al.,* 1998; Anderson, 1996). The measurements were taken with the joints in the neutral position to correspond with the zero reading of the measuring devices. The authors explained and demonstrated to the subjects the actual motions (PF and DF) expected at the ankle joints before measurements were taken. Manual stabilization of the foot was employed to train some of the subjects till they were able to carry out pure PF and DF after which measurements were then taken. In this way, possible associated motions of inversion and eversion of the subtalar joint were prevented during DF and PF measurements. The method of goniometric measurement employed was similar to that used by Slatyer and Hensley (1997). The technique of measurement involving the flexometer was similar to that used by Raab *et al* (1998).

Statistical Analysis

Descriptive statistics (mean ± standard deviation) were employed to describe the general characteristics of the subjects. One-tailed t-tests at 95% confidence interval were performed to test the significance of differences in the measurement of the mean range of movement of the ankle, in respect of DF and PF, respectively, between the two groups. The correlation coefficient (r) of the pairs of measurements obtained from the two measuring instruments (standard goniometer and flexometer) was determined.

Results

The results of both the goniometric and flexometric measurements are presented in Table 1. The range of ankle movement (DF and PF) was taken as an index of calf muscle flexibility. The measurements obtained with the two instruments were similar. Table 2 shows that the correlation coefficient (r) of the measurements obtained from the two instruments was 0.99, which is highly significant.

Focussing on the values obtained with the standard goniometer, the right and left ankles DF of the group 1 subjects (low-heeled shoe wearers) were significantly ($p < 0.05$) higher than those of the group 2 subjects (high-heeled shoe wearers). (Refer to Table 1). However, the right and left ankles' PF of the group 1 subjects were not significantly different from the group 2 subjects. The measurements from the flexometer gave an identical picture (see details in Table 1).

Discussion

The screening of the participating subjects ensured that none of them was suffering from peripheral arterial insufficiency or intermittent claudication. Hedberg *et al.* (1988) hinted that such conditions were capable of interfering with calf muscle flexibility and precipitating decreased walk tolerance. Slatyer *et al.* (1997) demonstrated in their study the usefulness and reliability of the standard goniometer as a clinical tool for measuring ankle range of motion. Raab *et al.* (1998) showed that muscle flexibility could be evaluated by means of a flexometer as well.

Notwithstanding these findings, the radiographic technique of measuring range of motion was considered the most accurate. The disadvantage of the radiographic technique is that it cannot be used routinely due to the potential carcinogenic effect of over exposure to X-rays. Therefore, evaluation of the ankle joint range of motion using standard goniometers has become a norm in clinical practice, despite the problems of intra- and inter-observer variations associated with it. In the hands of trained therapists, these variations have been found to be insignificant (Kofoed and Backer, 1989; Youdas *et al.*, 1993). As the results show (Table 1), the values obtained with both standard goniometer and flexometer are essentially alike. The significantly high correlation coefficient ($r = +0.99$) between the two instruments' measurements (Table 2) corroborated the fact that either of the instruments would yield reliable measures. It is against this background that the goniometric values are utilized in the context of discussion of this study in order to avoid repetition.

In general, low-heeled shoe wearers (group 1) have a higher DF range than high-heeled shoe wearers (group 2) ($p<0.05$). This result indicates an element of tightness in the calf muscles, thus imposing a limitation on the degree of possible DF at the ankles. On the other hand, the ranges of ankle PF in both groups are similar ($p > 0.05$). This indicates relative normal flexibility of the PF for both groups. As insignificant as it may be, it is still noteworthy to observe that the plantar flexion ranges of both right (48.05±4.86 degrees) and left (47.7±4.86 degrees) of group 2 subjects are respectively higher than the right (47.82±5.02 degrees) and left (47.07±5.47 degrees) of group 1 subjects. The relative increased plantar flexion range of the group 2 subjects is probably indicative of adaptive tightness of the muscles. Supposedly, adaptive tightness of the calf muscles may be a manifestation of shortened calf muscles resulting from constantly plantar flexed ankle joints imposed by high-heeled shoes. As a direct consequence, DF may be deemed to have become over stretched giving rise to the observed increased PF. In addition to the potential adaptive tightness of the calf muscles in the habitual high-heeled shoe wearers (group 2), as demonstrated in this study and supported by similar findings of Snow (1994), there is a possibility for greater energy consumption during walking in an effort to maintain stability due to small base of support (Ebbling, 1994).

The ranges of dorsiflexion of the group 1 subjects (26.57±4.54 degrees) for the right and (26.0±4.50 degrees) for the left were by far superior to the corresponding values for group 2 subjects, (15.40±5.10 degrees for the right) and (14.40±4.42 degrees for the left). However, when compared with the ranges obtained from other studies (Kitaoka, 1997; Michelsen and Helgemo, 1996), one can only conclude that the ranges for group 1 can still be improved upon.

Conclusion

Predominant or habitual wearing of high-heeled shoes as demonstrated in this study, has the potential hazardous effect on calf muscle flexibility. This opinion was supported by Raab et al. (1996). Muscle flexibility is very important for efficient muscle performance, general health and physical fitness (Hornsby *et al.*, 1987). There is a danger of progressively adaptive tightness of calf muscles, which may compromise ankle joint stability. High-heeled shoes cause the center of body mass to be moved forward thereby bringing about increase vertical ground reaction force on the forefoot during standing (Ebbeling *et al.*, 1995).

Finally, it is difficult to deduce that the Islamic kneel-sitting posture contributes to the plantar flexor tightness observed in group 2, because plantar flexion values of subjects in the two groups are not significantly different.

Table 1. Analysis of Ankle Joint Range of Motion (ROM) between Groups 1 & 2

	Low-Heeled Shoe (group 1)			High-Heeled Shoe (group 2)					
	Range of Motion by Flexometer								
	Mean (degrees)	SD	SEM	Mean (degrees)	SD	SEM	t-Test	P –value	
Rt. DF	26.55	4.62	0.73	15.20	4.61	0.73	11.00	<0.05	= 7.78E-18
Rt. PF	48.00	4.84	0.77	48.20	5.14	0.81	0.17	0.42*	
Lt. DF	26.32	4.17	0.66	14.32	4.17	0.66	12.87	<0.05	= 2.74E-21
Lt. PF	47.37	4.94	0.78	48.87	5.18	0.82	1.32	0.09*	
	Range of Motion by Standard Goniometer								
Rt. DF	26.57	4.54	0.72	15.40	5.10	0.81	10.35	<0.05	= 1.54E-16
Rt. PF	47.82	5.02	0.79	48.05	4.86	0.85	0.19	0.42*	
Lt. DF	26.00	4.50	0.71	14.40	4.42	0.70	11.63	<0.05	= 4.98E-19
Lt. PF	47.07	5.47	0.87	47.70	4.86	0.86	1.31	0.09*	

Key
SD = Standard Deviation. SEM = Standard Error of the Mean.
DF = Dorsiflexion. PF = Plantarflexion.
P= Confidence Interval at 0.05 (one-tailed). *No significant difference.

Table 2. Correlation of Measurements Obtained from the Two Measuring Instruments.

	Flexometer	Standard Goniometer
Mean	34.26	34.25
Range	5-57	5-59
Standard Deviation	15.13	15.09
Standard Error	0.84	0.84
Correlation coefficient	0.99	

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تأثير الحذاء ذي الكعب العالي والأوضاع المعتادة على مرونة العضلات الخلفية للساق

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المستخلص: تهدف هذه الدراسة إلى تقييم الأثر المزدوج لكل من إرتداء الحذاء ذي الكعب العالي وبعض الأوضاع الخاصة ،المعتادة لمفصل الكاحل على مرونة العضلات الخلفية للساق .

شملت الدراسة (80) طالبة بالجامعة تم تقسيمهن إلى مجموعتين متساويتين في العدد. الأولى، يرتدي أفرادها حذاء ذا كعب منخفض. يبلغ متوسط أعمارهن (21.7 ± 4.2 سنة) وأوزنهن (51.4 ± 11.4 سنة) وأطوالهن (155 ± 8.8 كجم).

أما الثانية ، يرتدي أفرادها حذاء ذا كعب عال. يبلغ متوسط أعمارهن (20.4 ± 5.1 سنة) وأوزنهن (52.7 ± 10.2 سنة) وأطوالهن (155 ± 6.7 كجم).

استخدم المدى الحركي لمفصل الكاحل (الأيمن والأيسر) كمؤشر لمدى مرونة المفصل عن طريق جهاز قياس المدى الحركي وجهاز قياس المرونة. أظهرت القياسات بواسطة الجهازين، إرتباطاً طردياً قوياً، حيث بلغ معامل الإرتباط (0.99 +). وبعد معالجة القياسات إحصائياً لكلا المجموعتين باستخدام إختبار (t) مع اختبار (0.5) كمستوى للثقة، إتضح أن هناك فروقاً ذات دلالة إحصائية لصالح المجموعة الأولي (الحذاء ذا المستوي المنخفض). الأمر الذي يشير إلى أن إرتداء الحذاء ذا الكعب العالي يسبب شداً عضلياً في عضلات الساق الخلفية، كما يُفقد هذه العضلات بعضاً من مرونتها، كما ينعكس ذلك بصورة مباشرة على إنخفاض المدى الحركي لمفصل الكاحل.

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