

Decrease in Talocrural Joint Mobility is Related to Alteration of the Arterial Blood Flow Velocity in the Lower Limb in Diabetic Women

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Abstract. [Purpose] The purpose of this study was to correlate the talocrural range of motion (ROM) and blood flow velocity in the lower limb arteries of diabetic women. [Subjects and Methods] Thirty women were divided into a control group (G1), consisting of 15 sedentary right-handed subjects (41.27 ± 7.24 years old) who had no history of blood system disorder, and a diabetes group (G2), consisting of 15 sedentary right-handed subjects (57.87 ± 6.20 years old) who had type 2 diabetes mellitus. Talocrural ROM was measured by using goniometry for dorsiflexion and plantar flexion movements. In addition, blood flow velocity of the dorsalis pedis, posterior tibial, and popliteal arteries was also assessed. [Results] No significant differences were found between the groups by comparing talocrural ROM and arterial blood velocity. However, a significant association was found in G2 only between the following variables: plantar flexion and blood flow velocity of the dorsalis pedis artery ($r_s = 0.57$), plantar flexion and blood flow velocity of the popliteal artery ($r_s = 0.50$), and dorsiflexion and blood flow velocity of the posterior tibial artery ($r_s = 0.57$). [Conclusion] The decrease in talocrural ROM is related to a decrease in the arterial blood flow velocity in diabetic women.

Key words: Diabetes mellitus, Arthrometry, Physical therapy

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INTRODUCTION

Diabetes is a systemic pathological condition that has implications for the locomotor system, which may affect muscle functioning¹⁾, joint structures^{2, 3)}, postural control⁴⁾, and peripheral nerve integrity⁵⁾. In this sense, the physiotherapist plays a key role in the rehabilitation of these patients, as knowing the changes in physiological mechanisms and their functional repercussions is an important factor for a successful therapy^{6, 7)}.

In this context, the flexibility within the ranges of joint integrity is a key condition for locomotor system functioning. Due to diabetes, one can observe reductions in joint mobility resulting from the process of nonenzymatic glycosylation of collagen, which increases the number of cross-linkages. Therefore, there is a greater accumulation of these cross-linkages in the extracellular matrix of the joint capsule, ligaments, tendons, and muscles, thus altering the mechanical properties of these tissues and reducing their elas-

ticity and resistance to traction and increasing mechanical rigidity^{2, 3, 8)}. In addition, it should also be emphasized that the ankle is one of the joints most affected by diabetes⁸⁾.

Another important measurement of corporal function is the peripheral arterial blood flow. One can observe that diabetic individuals are at a higher risk of developing occlusive vascular diseases as a result of the close relationship between diabetes and the process of atherogenesis. Therefore, hyperglycemia has several harmful repercussions on the vascular endothelium depending on the changes in the levels of nitric oxide, angiotensin II, prostacyclin, endothelin-1, plasminogen activator inhibitor-1, and others compounds^{9, 10)}. Although most of the cases with changes in peripheral arterial flow occur asymptotically, decreased blood flow has clinical implications such as presence of pain, ischemia, and metabolic failure¹¹⁾.

In view of the above and considering both blood flow and joint flexibility as two important components for performance of locomotor functions, the objective of the present study was to correlate the talocrural range of motion (ROM) and blood flow velocity in the lower limb arteries of diabetic women. Therefore, our hypothesis is that there is an association between the variables under study.

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SUBJECTS AND METHODS

The procedures in the present study were approved by the Ethics Research Committee of the Methodist University of Piracicaba (protocol number 105/04). All the volunteers confirmed their participation in the study by signing an informed consent form.

This was controlled cross-sectional study in which one physiotherapist performed the initial screening, a second one evaluated the talocrural ROM, a third one measured the blood flow velocity, and finally one researcher performed data and statistical analyses.

Thirty women were consecutively recruited from the communities of the city of Piracicaba (SP, Brazil) by means of verbal invitation, all being divided into two groups as follows: a control group (G1), consisting of 15 sedentary right-handed women with a mean age of 41.27 ± 7.24 years and no history of blood system disorder, and a diabetes group (G2), consisting of 15 sedentary right-handed women with a mean age of 57.87 ± 6.20 years and type 2 diabetes mellitus.

The exclusion criteria adopted for groups G1 and G2 were previous history of ankle lesion and regular practice of physical activities. Also, those volunteers presenting other circulation or orthopaedic-related disorders were excluded from G2.

Considering the eligibility criteria mentioned above, there was no sample loss in the present study.

The patients evaluated had diabetes for 7.50 ± 1.20 years, controlled by oral hypoglycemic agents, and presented mild or moderate peripheral arterial disease according to the ankle/brachial index.

Initially, in order to match the volunteers with the eligibility criteria, a questionnaire on personal data, daily habits, and previous family and disease history was applied. In addition, their lower limbs were evaluated by inspection and palpation.

Next, the arterial blood flow in the lower limbs was evaluated. To do, a portable Doppler device operating with continuous waves of 4 and 8 MHz was used for spectral analysis (VersaLab SE, Natus Medical Incorporated, San Carlos, CA, USA), thus allowing data on blood flow components such as velocity and direction to be measured and recorded in detail.

The volunteers were examined after a 10-minute rest period in the supine position. Data on the right lower limb were collected for the following sites: back of the foot, posterior region to the medial malleolus, and popliteal region with back of the foot positioned at 30 degrees in order to intensify the sound wave, thus forming a 45 degree angle in relation to the horizontal plane. Doppler signals were captured in the dorsalis pedis and posterior tibial arteries with an 8 MHz probe and in the popliteal artery with a 4 MHz probe, with the maximum blood flow velocity being used as a parameter. Three measurements were performed for each artery, and the mean value was used for statistic calculation.

Assessment of talocrural ROM was performed by a trained physiotherapist, who used a universal goniometer (CARCI, São Paulo, SP, Brazil). The volunteers remained in the dorsal decubitus position with a support beneath the

knees in order to avoid full extension of them. The goniometer's fixed arm was positioned at the lateral face of the fibula, whereas the movable arm was placed at the lateral face of the foot and the axis was placed at the ankle joint along with the lateral malleolus¹²⁾. In this way, the maximum plantar flexion and dorsiflexion movements could be always measured from a neutral position. For each movement, three measurements were performed, and the mean value was used for statistic calculation¹³⁾.

The Shapiro-Wilk test was used to assess data normality, whereas the Mann-Whitney test was used for comparison between groups. The associations between the variables were assessed by using the Spearman's correlation coefficient. Interpretation of the correlation coefficients was based on Munro's classification as follows: low, between 0.26 and 0.49; moderate, between 0.50 and 0.69; high, between 0.70 and 0.89; and very high, between 0.90 and 1.00¹⁴⁾. A significance level of 5% was considered for all statistical analyses. Data analysis was performed by using the BioEstat software, version 5.3 (Belém, PA, Brazil).

RESULTS

Tables 1 and 2 show the correlations between talocrural ROM and arterial blood flow in women from the control and diabetes groups, respectively. In G2, a significant, moderate and positive association was found between plantar flexion movement and blood flow in the dorsalis pedis ($r_s = 0.57$, $p = 0.02$) and popliteal ($r_s = 0.50$, $p = 0.04$) arteries as well as between dorsiflexion movement and the popliteal artery ($r_s = 0.57$, $p = 0.02$).

Tables 3 and 4 show the comparisons between groups regarding the talocrural ROM and blood flow velocity, respectively. No significant differences were found ($p > 0.05$).

DISCUSSION

In the present study, a positive correlation between arterial blood flow velocity and ankle joint flexibility was observed in diabetic individuals. Considering the harmful effects of diabetes on several tissues of the human body, one can emphasize the nonenzymatic glycosylation of collagen and its negative consequences with respect to joint flexibility as a possible physiopathological explanation for the findings reported in the present study^{2, 3, 8)}. Therefore, decreased ankle joint mobility in diabetic individuals brings a biomechanical disadvantage, with reduction in the effectiveness of the function of the sural triceps muscle pump, which has negative repercussions on the peripheral vascular system¹⁵⁻¹⁷⁾.

Besides the above-mentioned clinical aspects, there is an increased risk of atherogenesis with consequent reduction in vascular diameter due to the presence of chronic hyperglycemia, insulin resistance, and dyslipidemia¹⁸⁾. Complementarily, a study conducted by Ravikumar et al.¹⁹⁾ investigated the structural aspects of the arteries in diabetic individuals, such as the increase in arterial rigidity and impairment of endothelial function compared with a control group.

Additionally, diabetes also has negative repercussions on the musculoskeletal system. Within this context and

Table 1. Association between the talocrural range of motion (degrees) and maximum blood flow velocity (cm/s) in the arteries of the lower limb of the control group (G1)

Correlation	rs
Plantar flexion × dorsalis pedis artery	0.08
Plantar flexion × posterior tibial artery	0.49
Plantar flexion × popliteal artery	0.04
Dorsiflexion × dorsalis pedis artery	0.08
Dorsiflexion × posterior tibial artery	0.21
Dorsiflexion × popliteal artery	0.16

No statistical significance ($p > 0.05$, Spearman's correlation coefficient)

Table 3. Comparison of the talocrural range of motion (ROM) between the control (G1) and diabetes (G2) groups

Talocrural ROM	G1	G2
Plantar flexion (degrees)	36.07 ± 17.77	30.20 ± 9.55
Dorsiflexion (degrees)	14.93 ± 4.71	12.47 ± 5.95

No significant differences ($p > 0.05$, Mann-Whitney test)

considering the aging process, Leenders et al.¹⁾ noted that diabetic individuals have a decline in leg lean mass, muscle strength, and functional capacity compared with normoglycemic controls. Kalyani et al.²⁰⁾ also reported that older adults with diabetes have lower quadriceps strength resulting from the presence of comorbidities and walk slower than those without diabetes.

Based on the results found in the present study, one can highlight clinical implications such as the importance of considering ankle joint mobility as a key factor not only for locomotor function, as reported by Pandey and Andriacchi²¹⁾, Kleipool and Blankevoort²²⁾, and Vandervoort²³⁾, but also for good functioning of the peripheral vascular system¹⁵⁾. Looking at the previous literature, it can be seen that clinical trials have been performed with diabetic patients having peripheral vascular disease whose rehabilitation was based on ankle exercises^{24–26)}.

With regard to the values of the talocrural ROM, Marques¹²⁾ established dorsiflexion excursion of 0 to 20° and plantar flexion excursion of 0 to 45° as standards of normality in the population. Thus, in the present study, it was observed that the average values of dorsiflexion and plantar flexion in the diabetes group were reduced by approximately 38 and 33%, respectively, when considering the above normality values. However, despite this reduction, there was no significant difference when compared with control women.

With regard to the limitations of the present study, one can emphasize the lack of investigation of the presence of peripheral arterial disease in the volunteers and the use of convenience sampling. In addition, because strength and electric activity of lower limb muscles were not considered in the present study, it is suggested that further studies should be carried out to assess muscle behavior in relation

Table 2. Association between the talocrural range of motion (degrees) and maximum blood flow velocity (cm/s) in the arteries of the lower limb of the diabetes group (G2)

Correlation	rs
Plantar flexion × dorsalis pedis artery	0.57*
Plantar flexion × posterior tibial artery	0.30
Plantar flexion × popliteal artery	0.50*
Dorsiflexion × dorsalis pedis artery	0.29
Dorsiflexion × posterior tibial artery	0.57*
Dorsiflexion × popliteal artery	0.06

*Statistically significant ($p < 0.05$, Spearman's correlation coefficient)

Table 4. Comparison of maximum blood flow velocity between the control (G1) and diabetes (G2) groups

Artery	G1	G2
Dorsalis pedis (cm/s)	26.11 ± 11.71	26.51 ± 14.55
Posterior tibial (cm/s)	55.47 ± 13.06	40.91 ± 12.24
Popliteal (cm/s)	34.13 ± 6.59	41.00 ± 18.78

No significant differences ($p > 0.05$, Mann-Whitney test)

to both blood flow and joint flexibility and to correlate them. We also emphasize the importance of future interventional clinical investigations that consider the results of the present study.

In conclusion, considering the experimental conditions of the present study, the data showed that impairment of talocrural ROM is related to a decrease in arterial blood flow velocity in diabetic women.

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