The relation between plantar skin changes and vibration sensitivity in diabetes mellitus and diabetic peripheral neuropathy

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Summary

Mechanical skin properties (MSP) and vibration perception thresholds (VPT) help to detect the progression of diabetes mellitus (DM), diabetic peripheral neuropathy (DPN) and contribute to forecast associated diabetic foot ulcers [1,2]. Our results show a strong correlation between skin thickness and hardness for DM and a weak for DPN, which is in accordance with literature [1,2]. On contrary, MSP showed no influence on VPT in DM. However, in DPN thicker skin led to decreased sensitivity, as shown by [2]. We recommend to implement MSP in a comprehensive diabetic diagnosis as well as to monitor disease progression [4]. Future studies should also measure plantar foot areas without calluses to investigate possible correlations between VPT and MSP.

Introduction

The human foot plays an important role as a sensory organ for gait and balance [3]. Diseases such as DM and DPN cause sensory nerve impairment [2,4] and thus have a negative impact on these essential sensomotoric abilities. To prevent disease progression and severe consequences such as diabetic foot ulcers, early detection is essential. In this context the role of MSP in addition to VPT measurements is still an open question [2].

Methods

54 patients with DM (sex (m/f): 28/26, age: (m) 60.04±11.22yrs, (f) 57.88±14.31yrs) and 43 with DPN (sex (m/f): 31/12, age: (m) 68.96±7.03yrs, (f) 62.50±13.65yrs) were examined. VPT were measured at the first metatarsal head (MET I) using a vibration exciter at 30/200Hz. Additionally, skin hardness (durometer) and thickness (ultrasound) were determined. Due to heteroscedastic distribution, VPT-data were transformed logarithmically [5].

Results and Discussion

We found a strong correlation between skin thickness and hardness for DM ($rs=0.52$, $p<0.01$) but not for DPN ($r=0.21$, $p=0.17$). An increase in epidermal thickness is typical for DM, while a reduction is characteristic for DPN – both with a steadily increasing hardness [1,2]. The two MSP parameters showed no significant correlation to VPT for DM at both frequencies (30Hz: thickness: $r=0.03$, hardness: $r=0.1$; 200Hz: thickness: $rs=-0.15$, hardness: $rs=0.11$, $p>0.05$). Therefore, in contrast to recent discussions [2], diabetes related altering MSP seem not to compensate for sensory loss of vibration perception, which goes along with results in healthy subjects [6]. In DPN, we found a weak to moderate correlation between VPT at both frequencies only for skin thickness (30Hz: $rs=0.27$, $p=0.08$; 200Hz: $rs=0.43$, $p< 0.01$) (Figure 1).

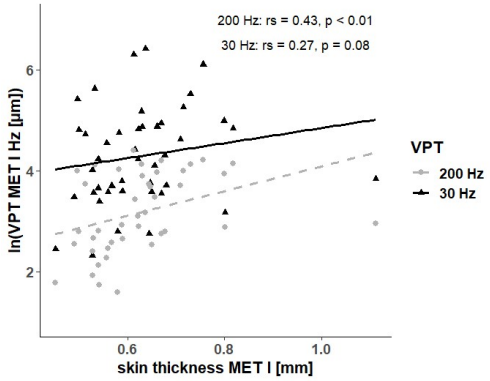

Figure 1: Spearman`s rank-order (rs) correlations between skin thickness and vibration perception threshold (VPT) for patients with diabetic peripheral neuropathy (DPN) at 30/200Hz. MET I: first metatarsal head., ln: natural logarithm.

Thus, thicker skin is associated with decreased vibration perception in DPN. From a pathophysiological perspective, DPN causes structural and functional changes of the foot [1]. This involves denervation processes and is responsible for a decrease in the quantity and sensibility of cutaneous mechanoreceptors [4]. Together with an atrophy of intrinsic foot muscles, DPN generally causes thinner but also stiffer plantar tissue [1]. Additionally, it leads to the formation of small-area calluses in areas with high plantar pressure [7]. Our measurement site at MET I was localized in an area, where thick calluses can be detected [1,7]. The more severe the neurodegenerative processes are - in our case quantified by VPT - the more callus formation occurs. This may have resulted in the observed correlation. However, callus thickness depends on influencing factors such as podiatric treatment intervals, the individual course of the disease or the general success of the therapy, which future studies should take into account.

Conclusions

We recommend to implement MSP in a comprehensive diabetic diagnosis as well as to monitor disease progression [4]. Future studies should measure plantar foot areas without calluses to investigate correlations between VPT and MSP.

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