PATIENTS WITH MEDIAL TIBIAL STRESS SYNDROME HAVE A LOWER STRUCTURAL COMPLEXITY OF FOOT MOVEMENT DURING GAIT THAN HEALTHY CONTROLS

[1] Michael Skovdal Rathleff; [2,3]Christian Gammelgaard Olesen, [4]Karsten Jensen , [5]Søren Kaalund, [3]Pascal Madeleine
[1]I Orthopedic Division, North Denmark Region, Aalborg Hospital - Aarhus University Hospital
[2]Department of Mechanical Engineering, Aalborg University, Denmark
[3]Department of Health Science and Technology, Aalborg University, Denmark
[4]Department of Development and Planning: Division of Geomatics, Aalborg University, Denmark
[5] Kaalunds Orthopedic Clinic**,** Aalborg, Denmark
email: misr@rn.dk

INTRODUCTION

Medial Tibial Stress Syndrome (MTSS) is a common diagnosis accounting for 6 to 16% of all running injuries and are responsible for as much as 50% of all lower leg injuries [1]. Traditionally gait analysis in patients with MTSS has used discrete measures such as navicula drop and rear foot movement. These parameters are usually used as descriptors of foot movement. Average dynamic navicula drop (ΔNH) and change in calcaneus angle (ΔCA) has been associated with MTSS. Gait analysis focuses in general on the properties of subjects average gait pattern and doses not take in consideration its fluctuations [2]. Indeed, the assessment of the variability during gait can be a way to assess important aspects of motor control. The magnitude of variability is measured by linear methods applied to the time series, but nonlinear analysis is required to investigate the structure of variability. The structure of variability provides information on the deterministic and stochastic organization of the signal investigated and is usually measured by computing the approximate or sample entropy (SaEn) of the time series. Larger SaEn value indicates more complex structure or lower predictability of the time series. Pool [3] proposed a hypothesis based on the importance of complexity. A loss of complexity or higher predictability (low SaEn values) would characterize patients' population.

The purpose of this study was to compare the structure of variability in foot movement descriptors, i.e. ΔNH and ΔCA between patients with MTSS and matched healthy controls. It was hypothesized that patients with MTSS will exhibit a lower structural complexity of foot movement than healthy controls.

METHODS

14 patients all diagnosed with MTSS and 14 matched controls were sequentially included from a local orthopedic clinic. MTSS was defined as continuous or intermittent pain in the tibial region, exacerbated during repetitive weight-bearing activity, and localized pain detected by palpation along the distal two thirds of the posterior-medial tibia.

A custom designed 3D multi video sequence analysis procedure was employed to assess ΔNH and ΔCA. The frame rate was set at 86 Hz. Markers on the medial side of the foot were placed on the 1) center of the first metatarsal head, 2) tuberositas navicula, and 3) medial side of calcaneus. Four markers were placed on the posterior part of calcaneus and tibia 2, 6, 13 and 17 cm above the floor level. ΔNH was calculated as the difference between navicula height at heel strike and the minimal height during stance phase. ΔCA was calculated as the difference between calcaneus angle at heel strike and maximal calcaneus angle during stance phase. SaEn was calculated for ΔNH and ΔCA during stand phase (N > 1000 samples) as an expression of the complexity. SaEn is the negative logarithm of the relationship between the probabilities that two sequences coincide for m+1 and for m points. The embedding dimension, m, and the tolerance distance, r, were set to m=2 and r=0.2×SD of the time series [4,5].

RESULTS AND DISCUSSION

	Controls	MTSS patients	P-value
ΔNH SaEn	1,02 (0,15)	0,85(0,17)	<0.05
ΔCA SaEn	1,28 (0,28)	1,05(0,36)	<0,05
Pain intensity*	0 (0 - 0)	6,5 (5 - 7)	<0,01
Duration of symptoms at baseline(months)*	0 (0 - 0)	30 (12 - 60)	<0,01

*presented as median (interquartil range)

The results confirmed our hypothesis as the gait pattern in patients with MTSS was characterized by lower structural complexity than healthy controls. We found a significant lower SaEn values in ΔNH and ΔCA in patients with MTSS than in healthy controls. The lower complexity or higher predictability found in MTSS patients corresponds to a higher degree of regularity. This trend may not be favorable as it could prevent appropriate adaptation to changes in sensory afferent feedback and may perpetuate and increase the risk for further damage [5] in the tibial region.

CONCLUSION

The present study confirms that non linear analysis is of relevance for the interpretation of kinematic data. Future studies should investigate (i) if lower complexity of kinematics data is associated with greater risk of overuse injuries such as MTSS and (ii) if appropriate interventions can lead to increase in kinematics data complexity.

ACKNOWLEDGEMENTS

Kaalunds Orthopedic Clinic**,** Aalborg, Denmark

REFERENCES

1. Kortebein PM et al. *Med Sci Sports Exerc* 2000 **32**:S27-S33.
2. Haussdorff JM. *Human Movement Science* **26** (2007) 555–589
3. Pool R. *Science* 1989 **3**:604-7.
4. Richman JS, Moorman JR. *Am J Physiol Heart Circ Physiol* 2000;**278**(:2039-2049.
5. Madeleine P, Madsen TMT. *Applied Ergonomics* (2009) doi:10.1016/j.apergo.2008.12.006