Variabilidade de sinais biológicos

MFT 5725 – Pesquisa clínica: delineamento, e condução, processamento de sinais biológicos e tratamento estatístico

Programa de Ciências da Reabilitação

Profa. Dra. Eneida Yuri Suda

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Sources of variability in computed tomography perfusion: implications for acute stroke management

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Object. Although dynamic, first-pass cerebral CT perfusion is used in the evaluation of acute ischemic stroke, a lack of standardization restricts the value of this imaging modality in clinical decision-making. The purpose of this study was to comprehensively review the reported sources of variability and error in cerebral CT perfusion results.

Methods. A systematic literature review was conducted. 120 articles were reviewed, and 23 published original research articles were included. Sources of variability and error were thematically categorized and presented within the context of the 3 stages of a typical CT perfusion study: data acquisition, postprocessing, and results interpretation.

Results. Seven factors that caused variability were identified and described in detail: 1) contrast media, the iodinated compound injected intravascularly to permit imaging of the cerebral vessels; 2) data acquisition rate, the number of images obtained by CT scan per unit time; 3) user inputs, the subjective selections that operators make; 4) observer variation, the failure of operators to repeatedly measure a perfusion parameter with precision; 5) software operational mode, manual, semiautomatic, or automatic; 6) software design, the mathematical algorithms used to perform post-processing; and 7) value type, absolute versus relative values.

Conclusions. Standardization at all 3 stages of the CT perfusion study cycle is warranted. At present, caution should be exercised when interpreting CT perfusion results as these values may vary considerably depending on a variety of factors. Future research is needed to define the role of CT perfusion in clinical decision-making for acute stroke patients and to determine the clinically acceptable limits of variability in CT perfusion results.

(DOI: 10.3171/2011.3.FOCUS1136)

Key Words • computed tomography perfusion • brain imaging • stroke • standardization

Neurosurg Focus 30 (6):E8, 2011

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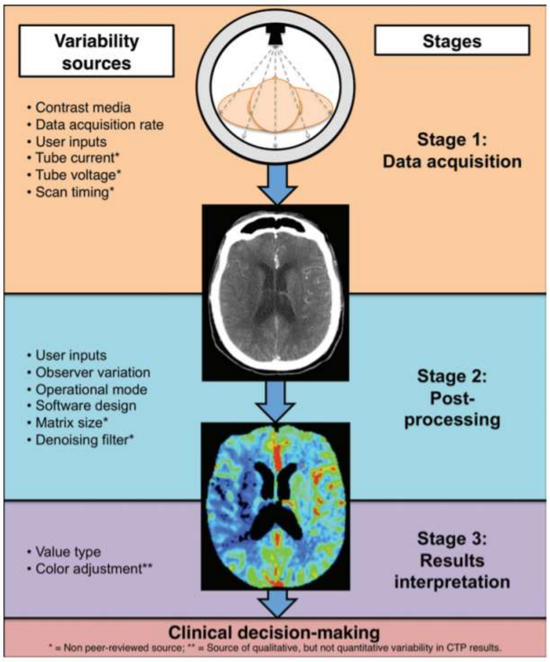

FIG. 3. Illustration of the sources of variability at different stages of a CT perfusion (CTP) study.

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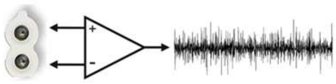
On the inter- and intra-subject variability of the electromyographic signal in isometric contractions



R. Correa Araujo, M. Duarte and A. Carlos Amadio [1]

Abstract

The objective of the present study was to evaluate the variability of the surface EMG signal of the same muscle in healthy subjects, because of lack of reproducibility of the EMG signal for the same subject and muscle in different trials of maximal isometric voluntary contraction. The results showed an EMG coefficient of variability of 21.61%, indicating that this variability must be considered in experiments with an inappropriate condition for normalization procedures, such as EMG biofeedback in rehabilitation sessions, or normalization procedures by the maximal isometric voluntary contraction.

Electromyogr. Clin. Neurophysiol., 2000, 40, 225-229.

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$$CV = \frac{desvio\ padrão}{média}\ x\ 100$$

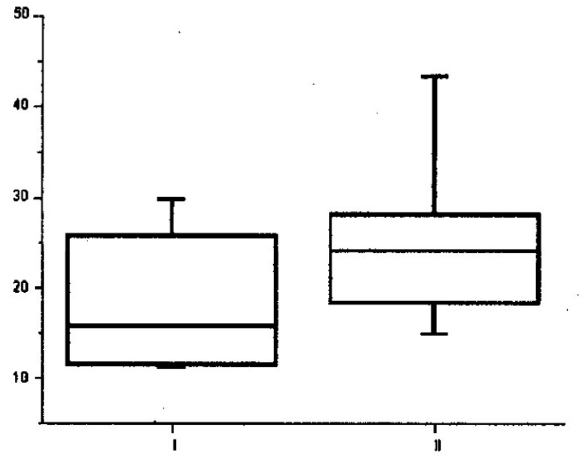

Fig. 2. – Graph showing the coefficient of variability (median and confidence interval) of the EMG signal registered during maximal isometric voluntary contractions in two different conditions. In condition I the electrodes were in the same place for all acquisitions, and in condition II the electrodes were alternated between the left and right side for each acquisition.

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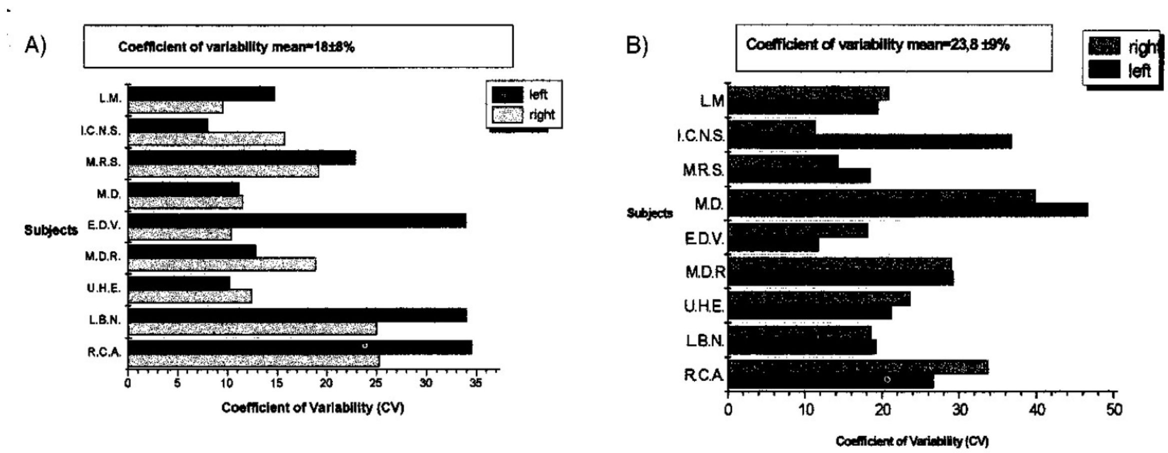

Fig. 1. – Coefficient of variability of the RMS values of the EMG signal of six trials from the right (R) and left L) m. tibialis anterior during MVIC. A) Trials for one side were recorded in sequence maintaining the electrode in the same place. B) Trials in which the leg of electrode placement was alternated between acquisitions.

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A.M. Burden et al. / Journal of Electromyography and Kinesiology 13 (2003) 519–532 525

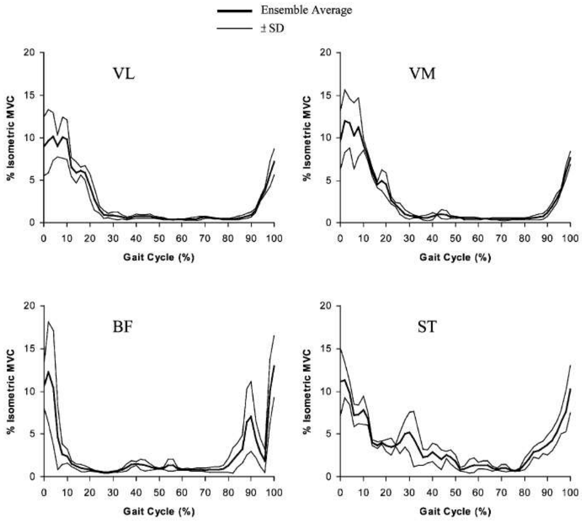

Fig. 2. Intra-individual ensemble average (± SD) of gait EMGs from the vastus lateralis (VL), vastus medialis (VM), biceps femoris (BF) and semitendinosus (ST) normalised using the *isometric MVC method*.

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Journal of Biomechanics 46 (2013) 1262–1268

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Contents lists available at SciVerse ScienceDirect

Journal of Biomechanics

journal homepage: www.elsevier.com/locate/jbiomech
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Heel-strike in walking: Assessment of potential sources of intra- and inter-subject variability in the activation patterns of muscles stabilizing the knee joint

CrossMark

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A B S T R A C T

The electromyographic (EMG) signal is known to show large intra-subject and inter-subject variability. Adaptation to, and preparation for, the heel-strike event have been hypothesized to be major sources of EMG variability in walking. The aim of this study was to assess these hypotheses using a principal component analysis (PCA). Two waveform shapes with distinct characteristic features were proposed based on conceptual considerations of how the neuro-muscular system might prepare for, or adapt to, the heel-strike event. PCA waveforms obtained from knee muscle EMG signals were then compared with the predicted characteristic features of the two proposed waveforms. Surface EMG signals were recorded for ten healthy adult female subjects during level walking at a self-selected speed, for the following muscles; rectus femoris, vastus medialis, vastus lateralis, semitendinosus, and biceps femoris. For a period of 200 ms before and after heel-strike, EMG power was extracted using a wavelet transformation (19–395 Hz). The resultant EMG waveforms (18 per subject) were submitted to intra-subject and inter-subject PCA. In all analyzed muscles, the shapes of the first and second principal component (PC-) vectors agreed well with the predicted waveforms. These two PC-vectors accounted for 50–60% of the overall variability, in both inter-subject and intra-subject analyses. It was also found that the shape of the first PC-vector was consistent between subjects, while higher-order PC-vectors differed between subjects. These results support the hypothesis that adaptation to, and preparation for, a variable heel-strike event are both major sources of EMG variability in walking.

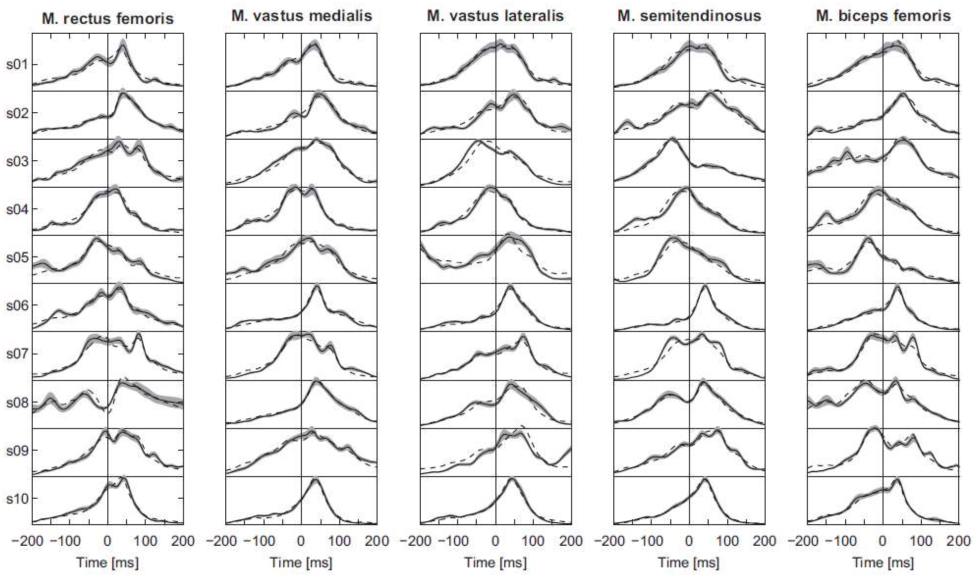

Fig. 2. The individual mean waveforms for each of the ten subjects (s01 to s10, solid black lines), and the waveforms reconstructed from the group mean waveform and the first three inter-subject PC-vectors weighted by the individual mean PC-scores (dashed black lines) for the following muscles: rectus femoris, vastus medialis, vastus lateralis, semitendinosus, and biceps femoris. Intra-subject variability is indicated by gray shaded areas representing the standard error of the mean calculated for each subject. Each waveform has been scaled by its maximum range. Time 0 indicates heel-strike (vertical black line).

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Repeatability and sources of variability in multi-center assessment of segmental foot kinematics in normal adults

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ARTICLE INFO

Article history:
Received 13 October 2008
Received in revised form 10 August 2009
Accepted 31 August 2009

Keywords:
Multisegmental foot/ankle model
Inter-site reliability
Repeatability
Variance components analysis

ABSTRACT

Multi-site application of biomechanical models can be a powerful tool as quantitative methods are employed to improve clinical care and to assess larger populations for research purposes. However, the use of such models depends on adequate validation to assure reliability in inter-site measures. We assessed repeatability and sources of variability associated with the assessment of segmental foot kinematics using the Milwaukee Foot Model during multiple testing sessions at two sites. Six healthy ambulators were instrumented and tested during comfortable ambulation; data were analyzed with variance components analysis using a mixed effects linear model. Results indicated that the largest source of variability was inter-subject; measurement error associated with Site and Session fell below 3.5° in over 80% of position measurements and below 2.5° in over 80% of ROM measurements. These findings support the continued use of the segmental foot model at multiple sites for clinical and research purposes.

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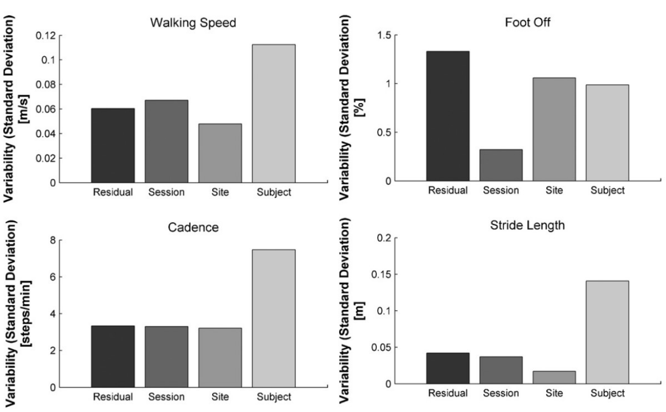

Fig. 2. Estimates of variability due to individual random effects (e.g. variability attributed to Site, Session, Subject, and measurement error Residual) for the specified temporal–spatial parameters. As these estimates are intended to represent variability in clinically relevant units, the standard deviation of the variance (square root) is reported.

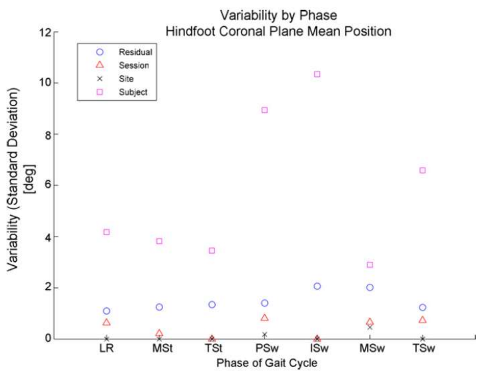

Fig. 1. Estimates of variability due to individual random effects (e.g. variability attributed to Site, Session, Subject, and measurement error Residual) across the gait cycle for mean position of the hindfoot in the coronal plane. As these estimates are intended to represent variability in clinically relevant units (degrees), the standard deviation of the variance (square root) is reported.

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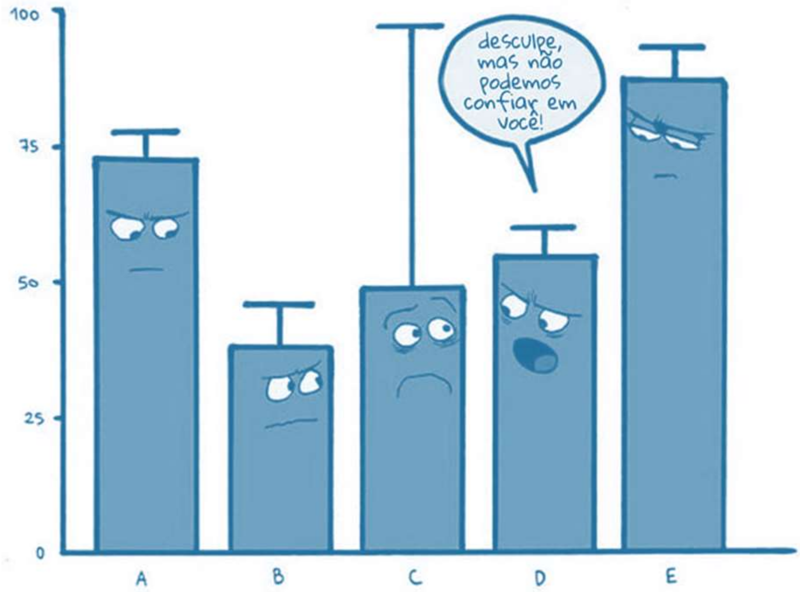


Variabilidade motora

- Variabilidade intrínseca presente em todas as ações controladas pelo sistema sensoriomotor

Variabilidade motora

- Observada em diferentes níveis de execução do movimento, em especial ao longo do tempo para o mesmo indivíduo

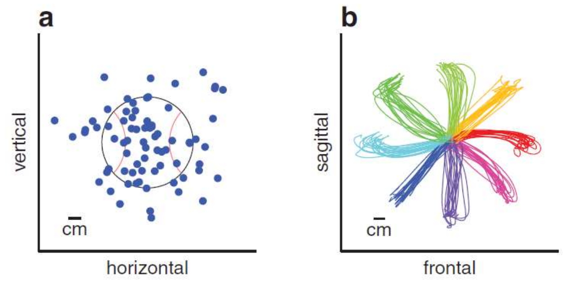


Figure 1. Examples of movement variability. ***a***, Spread of release points for all four-seam fastball pitches thrown by Los Angeles Dodgers pitcher Clayton Kershaw versus the New York Mets on May 8, 2011. The location is defined in the frontal plane of the pitcher but in coordinates fixed relative to the field. Baseball circumference shown for scale. ***b***, Reach paths from all tuning block trials in a single experimental session (monkey E, color coded by target).

Chaisanguanthum et al. J. Neurosci., September 3, 2014 • 34(36):12071–12080

Variabilidade motora x ruído

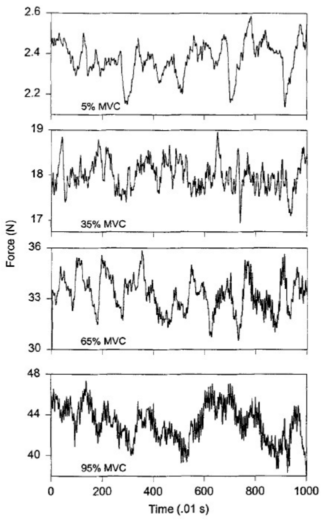


Figure 2. Examples of force–time series for continuous force production at force requirements based on 5%, 35%, 65%, and 95% of the maximum voluntary contraction (MVC). These examples were taken from the last force-production trial under the relevant force requirement. All four trials are taken from a single participant. Force output was sampled at 100 Hz or once every .01 s. The last 10 s of each of the 15-s trials are shown here. Force was measured in newtons.

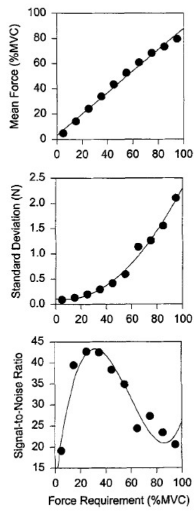


Figure 3. Changes in mean force (top), standard deviation (middle), and signal-to-noise ratio (bottom) as a function of force requirement. Force requirement and mean force produced are expressed as percentages of the maximum voluntary contraction (% MVC). The standard deviation was measured in newtons, and the signal-to-noise ratio (mean force [N] / the standard deviation [N]) is a unitless index. Each data point represents a group mean based on an average across five trials at each force requirement.

$$signal\ to\ noise\ ratio = \frac{mean\ force\ (N)}{standard\ deviation}$$

index of information transmission

Slifkin & Newell. J Experim Psychol: Human Perception and Performance. 1999, Vol. 25, No. 3, 837-851

Variabilidade motora

- Não é apenas ruído indesejável, mas apresenta um papel de importância funcional no desenvolvimento motor e na aquisição de habilidades

Desenvolvimento de um padrão de movimento adequado

\+

Desenvolvimento de novas soluções motoras em resposta a mudanças no ambiente externo ou na fisiologia interna

Controle ótimo do movimento
↓
Processamento e integração ótimos da informação

Abordagem – Sistemas dinâmicos

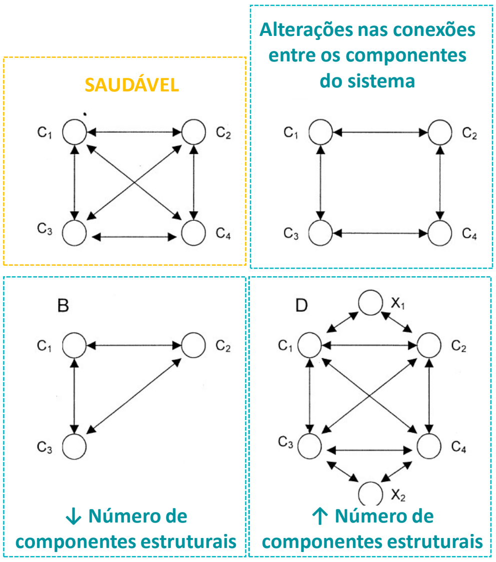
Variabilidade ótima assegura que novas soluções motoras podem ser exploradas em resposta a mudanças no meio externo ou na fisiologia interna do organismo

(Srinivasan & Mathiassen, 2012)

- Limite inferior: Comportamento motor se torna muito estereotipado

- Limite superior: Sistema superior se torna muito instável e sensível a perturbações

Stergiou et al., 2006



Vaillancourt & Newell, 2002

COMPLEXIDADE BIOLÓGICA

- Processos biológicos são regulados por mecanismos que operam em escalas múltiplas no tempo e espaço
- Habilidade de funcionar e se adaptar em um ambiente que está em constante mudança
- Surge da interação de unidades estruturais e alças de retroalimentação que operam para que o organismo se adapte a um ambiente não-estático

(Goldberg et al., 2002; Peng et al., 2009)

Gait & Posture 74 (2019) 194–199

Contents lists available at ScienceDirect

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Full length article

Impact of diabetic neuropathy severity on foot clearance complexity and variability during walking

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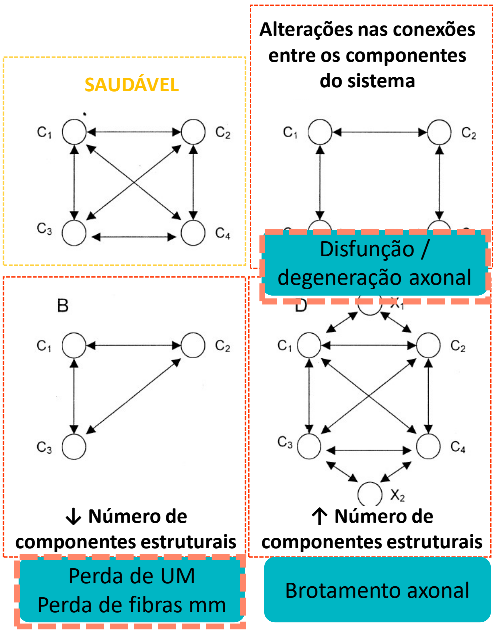
Doença

Neuropatia diabética – Alterações funcionais e estruturais que irão afetar as interações entre o sistema musculoesquelético e as demandas mecânicas do meio ambiente e da tarefa motora

↓ Capacidade adaptativa do sistema

Degradação da complexidade biológica

(Peng et al., 2009)



NEUROPATIA DIABÉTICA

Abordagem – Sistemas dinâmicos

Variabilidade ótima assegura que novas soluções motoras podem ser exploradas em resposta a mudanças no meio externo ou na fisiologia interna do organismo

(Srinivasan & Mathiassen, 2012)

- Limite inferior: Comportamento motor se torna muito estereotipado

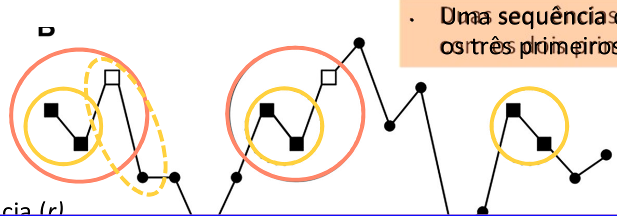
- Limite superior: Sistema superior se torna muito instável e sensível a perturbações

Stergiou et al., 2006

Sample entropy (*SaEn*)

- Fornece a medida de "estrutura ordenada" em uma série temporal
- Testa se há padrões repetidos de diferentes comprimentos, incluindo aqueles que podem não estar se repetindo em intervalos regulares

- $m = 2$
- $m+1 = 3$



- Uma sequência que coincide com os três primeiros pontos

Dentro de um nível de tolerância (r)

Valores baixos de *SaEn* = alto grau de regularidade

SaEn = logaritmo natural negativo da razão entre o número de combinações de tamanho *m*+1 e o número de combinações de tamanho *m*

$$SaEn(m,r,N) = -\ln\left(\frac{\Phi^{m+1}(r)}{\Phi'^{m}(r)}\right)$$

Gait & Posture 74 (2019) 194–199

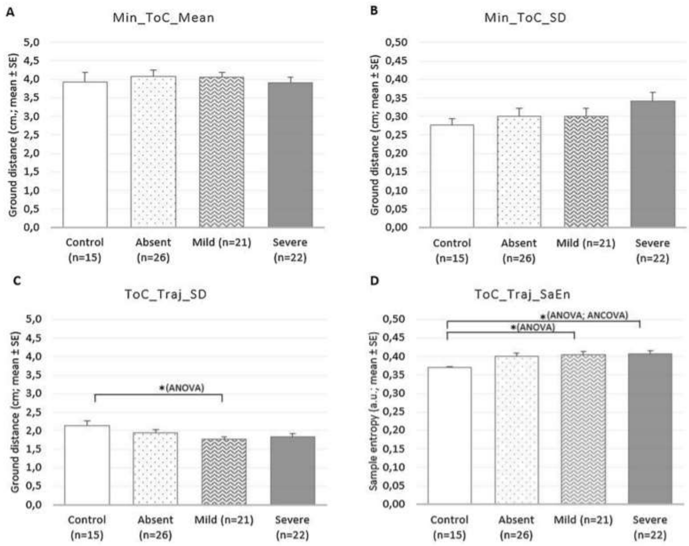


Fig. 2. Minimum toe clearance mean values (Min_ToC_Mean) (A, in the top left, mean ± SE), minimum toe clearance values variability between trials (Min_ToC_SD) (B, in the top right, mean ± SE), toe clearance trajectory amount of variability (ToC_Traj_SD) (C, in the bottom left, mean ± SE), and toe clearance trajectory sample entropy (ToC_Traj_SaEn) (D in the bottom right, mean ± SE) for the studied groups. *Shows the significant differences between groups, pointed out by the horizontal black lines for ANOVAs and ANCOVAs (Bonferroni pairwise comparisons, $P < 0.05$).