Journal of Ergonomics
ISSN: 2165-7556

Samani, J Ergonomics 2013, 3:2
DOI: 10.4172/2165-7556.1000118

Short Communication Open Access

ErgoVar: A Toolbox for Exposure Variation Analysis

Afshin Samani*

Laboratory for Ergonomics and Work-related Disorders, Center for Sensory-Motor Interaction (SMI), Department of Health Science and Technology, Aalborg University, Denmark

Abstract

Ergonomists suggest that increasing exposure variation at work may prevent development of work related musculoskeletal disorder in the jobs which are characterized by repetitive pattern of exposure. However, different methodological approaches could be adopted to quantify exposure variation. ErgoVar provides the implementation of relevant computational methods for analysis of exposure variation. It consists of a set of linear and nonlinear processing methods relevant to exposure variation analysis. It is free for downloading and sharing. ErgoVar aim is to facilitate the research focusing on exposure variation.

Introduction

Lack of exposure variation has been suggested to be associated with development of work related musculoskeletal disorder in "repetitive works" [1]. As a remedy, ergonomists have suggested exploiting of redundancy of human motorcontrol toincrease the variation in pattern of biomechanical loading [2,3]. Further, a similar concept has attracted attention within the sport science field where the implication of the motor variability in sport activities has been introduced in skill achievement and susceptibility to injuries [4].

What is known as motor variability reflects the observed variability at different levels of movement execution across time and within individuals [5]. This variability can be observed in the kinetic and kinematic properties of end-point or joint angles as well as variability of muscular activity of muscles within or outside the same muscular synergy. However, a sophisticated universal index to quantify and interpret motor variability is still absent or may be non-existing because variability has different aspects that cannot be reflected in only one index [5]. While some previous studies have reported cycle-to-cycle standard deviation as an index of variability [2,6], more recent studies have addressed the complexity and stability as different aspects of motor variability [7,8]. Systematically speaking, different approaches of variability quantification methods could be categorized into linear and non-linear methods [9].

Heterogeneity and variety of studies in this field call for an integrated framework to establish a comparable and easy to use base for the studies in this field. ErgoVar is a framework which consists of several functionalities including aforementioned quantification methods and allows the researchers in the field to take benefit of the proposed methods in their own research.

Availability of such application may facilitate the research in this field and renders a comparable base between different studies. To my best knowledge, there is no collective package with this particular focus on exposure variation for the researchers in this field. The current short communication introduces different functionalities of ErgoVar and potential application of this framework.

ErgoVar Environment

ErgoVar is the results of efforts put into analysis of biomechanical exposure variation over several years and now it is developed to be an open-source toolbox in MATLAB that allows quantification of exposure variation using several methods.

ErgoVar can be accessed via the following webpage http://smi.hst.aau.dk/research/projects/ergovar/download/

ErgoVar is implemented using a graphical user interface and the users of this application do not need to have extensive knowledge on how to use MATLAB.

Functionalities of ErgoVar

ErgoVar consists of linear and non-linear approaches of exposure variation quantifications. In addition to conventional statistical descriptors, e.g.,coefficient of variation, exposure variation analysis (EVA) [10], cluster-based exposure variation analysis (C-EVA) [11] can be studied. From the category of non-linear methods, entropy measures and recurrent map analysis (RQA) are also included (see figure 1).

Exposure variation analysis: EVA was first introduced about two decades ago as a general computational framework for exposure variation quantification in ergonomic studies [10] and it has been subsequently used in several other studies in its original or a modified format [12,13]. ErgoVar provides a simple interface for users to modify the layout of EVA according to their own application and obtain the analyzed results.

Cluster-based exposure variation analysis: C-EVA is a very recent modification of EVA to optimize its layout and allow a multivariate setup to include time line of exposure variation from multiple sources [11]. Instead of splitting the exposure level into exposure classes, C-EVA works based on a data clustering algorithm. This is now available in ErgoVar environment.

Entropy measures: Entropy measures quantify what is known as complexity of a signal and thus introduce a new aspect of variability. For the first time, this category of measures was utilized to verify the principal of "loss of complexity" in pathological cases compared with healthy physiological systems [14]. As a computational tool, entropy

***Corresponding author:** Afshin Samani, Laboratory for Ergonomics and Work-related Disorders, Center for Sensory-Motor Interaction (SMI), Department of Health Science and Technology, Aalborg University, Fredrik Bajers Vej 7 D-3, 9220 Aalborg East, Denmark,Tel: +4599402411; Fax: +4598154008; E-mail: afsamani@hst.aau.dk

Received May 30, 2013; **Accepted** July 28, 2013; **Published** July 30, 2013

Citation: Samani A (2013) ErgoVar: A Toolbox for Exposure Variation Analysis. J Ergonomics 3: 118. doi:10.4172/2165-7556.1000118

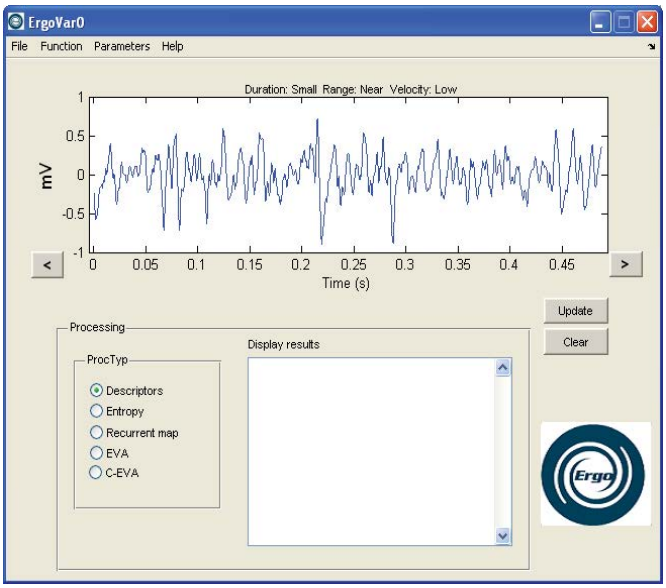

Figure 1: Processing panel of ErgoVar.

measures quantify the complexity of the signals such that the higher the entropy values, the more complex the signal.

ErgoVar can compute sample entropy and its permuted version as well as permutation entropy [15-17]. Additionally, it can compute multi-variate multi-scale entropy defined by Ahmed et al (2012) [18]. Users have the possibility to adjust the parameters of the algorithms and the results will be stored for further analysis.

Recurrent map analysis: RQA is comprised of indices which quantify the recurrence pattern of observations and thereby reveal some information about the complexity of underlying systems. RQA has been used in processing of biological signals and in some cases it performed better than some other conventional methods [19,20]. ErgoVar can compute the most frequently used indices from the recurrence maps.

Recurrent percentage (Rec%), Determinism (Det%), maximum length of a vertical line in the recurrence map (LINMAX), entropy of the map (ENT), trend (TND), Laminarity (LAM%), maximum length of a horizontal line in the recurrence map (LINMAX_LAM) can be computed. The recurrence map is based on reconstructing the embedding space and ErgoVar also presents tools to find proper values for the parameters of embedding space reconstruction [21].

Conclusion

ErgoVar as a package is developing to include any potentially relevant method for exposure variation analysis. The routines of the software have been tested on some synthetic inputs as introduced in the referenced articles and identical outcomes were observed. Thus, the accuracy of implemented methods is, in turn, identical to those reported in the referenced articles and it also faces with all limitations that the referenced papers have previously reported. However, ErgoVar is provided "AS IS" and expressly disclaims all warranties. ErgoVar is distributed under the General Public License (version 3 or later).

Acknowledgment

I would like to appreciate inspiring discussions with Prof. Svend Erik Mathiassen and Pascal Madeleine. This work was financially supported by the Danish Council for Independent Research Technology and Production Sciences (FTP). Grant number: 10092821.

References

1. Mathiassen SE (2006) Diversity and variation in biomechanical exposure: what is it, and why would we like to know? Appl Ergon 37: 419-427.
2. Mathiassen SE, Möller T, Forsman M (2003) Variability in mechanical exposure within and between individuals performing a highly constrained industrial work task. Ergonomics 46: 800-824.
3. Madeleine P (2010) On functional motor adaptations: from the quantification of motor strategies to the prevention of musculoskeletal disorders in the neck-shoulder region. Acta Physiol (Oxf) 199 Suppl 679: 1-46.
4. Bartlett R, Wheat J, Robins M (2007) Is movement variability important for sports biomechanists? Sports Biomech 6: 224-243.
5. Srinivasan D, Mathiassen SE (2012) Motor variability in occupational health and performance. Clin Biomech (Bristol, Avon) 27: 979-993.
6. Möller T, Mathiassen SE, Franzon H, Kihlberg S (2004) Job enlargement and mechanical exposure variability in cyclic assembly work. Ergonomics 47: 19-40.
7. Dingwell JB, Marin LC (2006) Kinematic variability and local dynamic stability of upper body motions when walking at different speeds. J Biomech 39: 444-452.
8. Søndergaard KH, Olesen CG, Søndergaard EK, de Zee M, Madeleine P (2010) The variability and complexity of sitting postural control are associated with discomfort. J Biomech 43: 1997-2001.
9. Madeleine P, Madsen TM (2009) Changes in the amount and structure of motor variability during a deboning process are associated with work experience and neck-shoulder discomfort. Appl Ergon 40: 887-894.
10. Mathiassen SE, Winkel J (1991) Quantifying variation in physical load using exposure-vs-time data. Ergonomics 34: 1455-1468.
11. Samani A, Mathiassen SE, Madeleine P (2013) Cluster-based exposure variation analysis. BMC Med Res Methodol 13: 54.
12. Delisle A, Larivière C, Plamondon A, Imbeau D (2006) Comparison of three computer office workstations offering forearm support: impact on upper limb posture and muscle activation. Ergonomics 49: 139-160.
13. Straker LM, Coleman J, Skoss R, Maslen BA, Burgess-Limerick R, et al. (2008) A comparison of posture and muscle activity during tablet computer, desktop computer and paper use by young children. Ergonomics 51: 540-555.
14. Lipsitz LA (2006) Aging as a process of complexity loss. Complex Systems Science in Biomedicine, Springer, USA.
15. Richman JS, Moorman JR (2000) Physiological time-series analysis using approximate entropy and sample entropy. Am J Physiol Heart Circ Physiol 278: H2039-2049.
16. Bandt C, Pompe B (2002) Permutation entropy: a natural complexity measure for time series. Phys Rev Lett 88: 174102.
17. Samani A, Madeleine P (2010) Permuted sample entropy. Commun Stat Simul Comput 39: 1506-1516.
18. Ahmed MU, Mandic DP (2012) Multivariate multiscale entropy analysis. IEEE Signal Process Lett 19: 91-94.
19. Webber CL Jr, Zbilut JP (1994) Dynamical assessment of physiological systems and states using recurrence plot strategies. J Appl Physiol.76: 965-973.
20. Webber Jr CL, Zbilut JP (2005) Recurrence quantification analysis of nonlinear dynamical systems. Recurrence Quantification Analysis, National Science Foundation, USA.
21. Kantz H, Schreiber T (2004) Nonlinear Time Series Analysis. Cambridge University Press, UK.