OCCUPATIONAL OUTLIERS: STOCHASTICITY AND DETERMINISM IN OCCUPATIONAL BIOMECHANICS

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Omnipresent variability is likely amongst the first and most common confounders most biomechanists encounter when investigating human kinematics, kinetics, and the behaviour of the musculoskeletal system when performing activities. This is reflected by the pervasiveness of statistical analyses in biomechanical research, and the large magnitudes of variability in most biophysical measures.

In the subset of tasks deemed occupational, which can be rather inclusive depending on the definition, multiple sources of variability combine to complicate work task analyses and occupational design approaches, but are not always considered. Focusing on physical ergonomics, three major umbrella categories of occupational variability are: 1) variability in task performance – i.e. how a person performs a specified task; 2) variability in tissue response– i.e. how different persons are affected by common task requirements; and 3) variability in exposure – i.e. how different tasks or subtasks have different requirements. These sources interact to produce many potential injury or overexposure scenarios.

The issue of variability and potential injury is exemplified by considering subacromial impingement as a successor to shoulder muscle fatigue. In this previously published study (Chopp et al., 2010), a relatively homogenous group of young male subjects were exercised to fatigue through performance of a specified task that included overhead work and internal and external axial humeral rotation. Humeral superior migration, which has been linked to rotator cuff damage, was measured with radiographs at several arm elevation angles. The variability in response is dramatic (Figure 1).

Consideration of the mean response elicits only moderate concern at most elevation angles, but individual responses are alarming in some cases. This is shown by overlapping reported distributions (estimated from empirical data [1,2]) of humeral excursion magnitudes along with reported available subacromial width (Figure 2). Further, this example focuses on two variability sources: biological (congenital) musculoskeletal geometry and fatigue response, which are a subset of the possibilities. Indeed, despite highly controlling specific exposures and the subject population, high variability still existed. Other sources indicate even higher levels of variability [3,4]. Additionally, this data was pooled over arm angles, and understates the potential for injury under specific conditions.

Fig. 1. Variation in humeral head migration following a fatiguing protocol across angles. Outliers (+/- 2 SD) are indicated by circles, individual data points by diamonds, and standard errors by the shaded areas. Adapted from [1].

This symposium brings together researchers from across Canada to discuss variability within the three areas of variability indicated. First, Dr. Dickerson (Waterloo) will describe techniques and approaches to accounting for variability in occupational biomechanical analysis, and indicate how common such methods are. Secondly, Dr. Hubley-Kozey (Dalhousie) will speak to variability of exertion performance, specifically in a return-to-work framework. Third, Dr. Kier (McMaster) will provide commentary on variability in tissue response to load, with a focus on the carpal tunnel. Fourth, Dr. Beach will detail differences in occupational exposure in a set of firefighting tasks, and implications for musculoskeletal risk exposure. The symposium will conclude with a panel discussion in which the current state and future of accounting for variability in occupational biomechanics will be discussed.

REFERENCES