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Detailed assessment of low-back loads may not be worth the effort: A comparison of two methods for exposure-outcome assessment of low-back pain

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A B S T R A C T

The trade-off between feasibility and accuracy of measurements of physical exposure at the workplace has often been discussed, but is unsufficiently understood. We therefore explored the effect of two low-back loading measurement tools with different accuracies on exposure estimates and their associations with low-back pain (LBP).

Low-back moments of 93 workers were obtained using two methods: a moderately accurate observation-based method and a relatively more accurate video-analysis method. Group-based exposure metrics were assigned to a total of 1131 workers who reported on their LBP status during three follow-up years. The two methods were compared regarding individual and group-based moments and their predictive value for LBP.

Differences between the two methods for peak moments were high at the individual level and remained substantial at group level. For cumulative moments, differences between the two methods were attenuated as random inaccuracies cancelled out. Peak moments were not predictive for LBP in any method while cumulative moments were, suggesting comparable predictive values of the two methods. While assessment of low-back load improves from investing in collecting relatively more accurate individual-based data, this does not necessarily lead to better predictive values on a group level, especially not for cumulative loads.

1. Introduction

Exposure to physical risk factors at the workplace such as lifting, pushing, pulling, and awkward trunk postures (e.g., flexion and rotation) has been associated with low-back pain (LBP; da Costa et al., 2010; Griffith et al., 2012; Lötters et al., 2003). However, it has also been argued that evidence concerning such work related risk factors for LBP is weak and inconsistent (Bakker et al., 2009; Kwon et al., 2011), potentially due to insufficient high quality studies using accurate objective measurement methods (Burdorf, 2010; David, 2005). An important potential reason for this is that the choice for a measurement method for occupational physical exposure involves a trade-off between accuracy and feasibility (i.e., in time and costs). As an example, although self-reports of physical exposure are frequently used as they can be obtained with relative ease and few expenses, outcomes are highly subjective and often based on rough categorization, thereby limiting accuracy (Balogh et al., 2004; Punnett, 2004). As a result, in theory, the choice of such methods in view of available resources, is expected to affect accuracy of exposure estimates which may bias risk associations (Tielemans et al., 1998) and reduce statistical power (Mathiassen et al., 2002, 2010). However, in practice, this is not always the case in epidemiological literature, since studies that measure more

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accurately often measure limited amounts of subjects which reduces the power of the given study (Griffith et al., 2012). Therefore, the effect of the accuracy of a chosen measurement method on exposure-outcome associations for occupational physical exposure risk factors of LBP is not well understood.

Mechanical low-back load as a result of exposure to physical load at the workplace (e.g., lifting and trunk flexion) is an appropriate load measure and is expected to be an important determinant of LBP (Chaffin, 2009; Wells et al., 2004). Such loads (i.e., low-back moments or forces on the lumbar spine) are suspected to provide a direct relationship with spinal failure and consequently with LBP. Mechanical low-back loads can be obtained from measured hand forces and structured posture observations as inputs in a biomechanical model in epidemiological studies (e.g.; Neumann et al., 2001). It has however been shown that these methods can lead to large inaccuracies (de Looze et al., 1994). Nevertheless, such estimates are predictive for LBP (Coenen et al., 2013b; Norman et al., 1998) and more valid and reliable methods for mechanical low-back loads, such as direct measurement techniques (i.e., combining information from motion tracking systems and external force measurements; Kingma et al., 2010; Marras et al., 2010a; Plamondon et al., 1996) can potentially lead to more accurate estimates and to less biased associations with LBP. However, in accordance with abovementioned trade-off, such methods are often costly and difficult to apply to a field setting, as they may interfere with the work performed (Trask et al., 2007). Posture fitting on planar video recordings during manual materials handling tasks has been shown to be a feasible and accurate method for application in field settings (Chang et al., 2003; Coenen et al., 2011; Xu et al., 2011). Yet, such methods are time-consuming and only allow analysis of selected tasks rather than continuous monitoring.

To date, the optimum of the above-mentioned trade-off, indicating which measurement tool for occupational low-back load assessment should be chosen in order to have the best combination of measurement accuracy and feasibility, is unknown. We therefore explored this trade-off by comparing the assessment of low-back loads based on observations (Coenen et al., 2013b) and low-back loads assessed more accurately using detailed video-analysis (Coenen et al., 2011). The two methods were compared, at both the individual and group levels, in terms of the accuracy of load estimates and predictive values regarding LBP prevalence.

2. Methods

2.1. Population and data collection

Data were collected as part of the SMASH study (Ariëns et al., 2001; Hoogendoorn et al., 2000) involving workers in a baseline measurement protocol, in which occupational low-back load was assessed at the workplace. Workers were recruited from 34 companies in the Netherlands representing several industrial and service branches, including metal, computer software, chemical, pharmaceutical, food and wood construction industries, as well as insurance companies, childcare centers, hospitals, distribution companies and road worker organizations. The study population thus included workers performing diverse tasks with a wide range of physical and mental workloads.

During the SMASH study, videos were collected at four randomly chosen instants in one day. Videos were collected for 5–15 min during each of the four occasions, depending on the variability of the worker's task, to obtain a representative sample of the worker's jobs. During these periods, external forces at the hands were measured when present, using force transducers (for pushing and pulling tasks) or weighting scales (for lifting tasks). For pushing and pulling tasks, a measured horizontal direction of the force was assumed and a single measured value of the transducer was used. For lifting, measured weights were used as input in the two methods, as will be outlined in detail later.

A three year annual follow-up assessment of LBP was performed using a self-administered Dutch version of the Nordic Questionnaire (Kuorinka et al., 1987). LBP was defined when a worker reported regular or prolonged LBP during at least one of the three years of follow-up. This definition of LBP prevalence was independent from LBP status at baseline. Regular or prolonged LBP was assessed based on self-reports and was thus not based on medical diagnosis, nor was it related to a specific incident or cause.

For the current study, of the 1802 workers who completed the baseline questionnaires (regarding personal information such as age, gender and LBP prevalence), LBP data in at least one of the years of follow-up were available for 1131 of them. These workers were a-priori allocated to occupational groups with similar tasks and physical loads based on the International Standard Classification of Occupations. These occupations were then again, based on expert judgments composed into 23 groups. These groups, such as a group of workers performing mainly *sitting tasks with varying postures* or *alternating standing, walking and/or sitting without external forces* were solely based on the expected physical work load without any prior knowledge on the actual quantified physical work load, baseline LBP status and/or psychosocial or workplace factors. This expected physical work load was subjectively assessed after watching the video by observers that were recruited among students of the Faculty of Human Movement Sciences of the VU University, Amsterdam and were extensively trained on the task. This classification scheme has been shown to be effective, leading to substantial between-group variation in low-back load variables in earlier work (Coenen et al., 2014b). Moreover, applying a group-based measurement approach has been shown to be an efficient strategy leading to more reliable estimates of exposure, since random measurement errors in individual estimates of exposure may decrease (Hoozemans et al., 2001; Jansen et al., 2003).

For the current study, data of those 19 groups of which video material was available for at least 4 workers were used (Table 1). Videos of these workers were observed during which manual material handling (MMH) tasks, i.e., lifting, pushing and pulling, were identified. From each group, four or if available five workers were randomly selected from whom all MMH tasks that occurred during the video recording were identified. As a result, 4872 MMH tasks of a total of 93 workers were analysed in the current study (Table 1). The use of this selection has been shown to be effective in assessing exposure-outcome associations (Coenen et al., 2014a) while it has also been shown that adding more workers per group does not lead to a considerably higher precision and power of the study outcomes (Coenen et al., 2014b). Low-back moments of all identified MMH tasks were subsequently assessed using two methods that will be described in the following paragraph.

2.2. Assessment of low-back moment

All selected videos of MMH tasks were used for low-back moment assessment with two different methods that have been described in more detail previously (Coenen et al., 2014a, 2013b). In the first assessment method, a procedure was performed in which postural observation data were used as inputs to a biomechanical model (Coenen et al., 2013b). Structured continuous observations of body segment positions (i.e., trunk flexion, trunk rotation and arm elevation in the dominant arm) were applied to the complete video material. Subsequently, to get a fair comparison with the second method that will be described below, only observations of the 4872 MMH tasks of the 93 selected workers were selected for