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A Proposal of Allostatic Load Operationalization Within Homeostatic Range - Occupation as a Risk Factor and Self-Rated Health as Outcome

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Abstract Allostatic load (AL) has been defined as the wear-and-tear on the body due to chronic dysregulation of different physiological systems. AL is considered an early health indicator that reflects mainly exposure to poor psychosocial conditions and, as well, an early predictor of more serious diseases. Traditionally, AL has been measured by counting the number of biomarkers that fall in the highest risk quartile for the population being studied. This operationalization presents a number of problems because the high-risk group includes biomarkers on the verge of clinical significance and also those that have already exceeded it. In this paper, a new operationalization of AL is proposed in which workers who have already lost homeostasis (as indicated either by biomarkers in a high-risk category or having a diagnosed disease) are excluded and high risk quartiles are calculated for the remaining working population. This operationalization of AL is tested using data from Chile's Second National Health Survey. AL was measured using five secondary biomarkers (blood glucose, systolic blood pressure, diastolic blood pressure, resting heart rate, and body mass index). AL cutoffs were established for each of these biomarkers by calculating their highest quartile. For each individual, the number of biomarkers that exceeded the highest quartile was counted. The associations between AL and self-reported health (SRH) indicators and Occupation (ISCO-88, four digits) were analyzed using weighted robust Poisson regression. While controlling for age and sex, there was a strong positive association between the SRH indicators and AL as well as AL with occupation. If findings are replicated, AL may have more importance as the effects of preventive tools and also health prognosis in the workplace.

Keywords: allostatic load; self-reported health, workers health

1. Introduction

The search for workers' health indicators has been an important moving target throughout the history of occupational health. These indicators have a dual usefulness in the web of causation in the workplace. On one side they can be used as the outcome of exposures and on the other side they can be used as predictors of future health. Allostatic load (AL) has become a highly used "early" health indicator. AL has been conceptually defined as the dynamic process that allows the body to have a broad range of responses to challenging external or internal environments in order to maintain homeostasis (Beckie, 2012; Seeman, Singer, Roew, Horwitz & McEwen, 1997). AL has been found to be consistently associated with exposure to environmental stressors (Beckie, 2012; McEwen, Gianaros, 2011) and predictive of disease outcomes and mortality (Seeman, Singer, Roew, Horwitz & McEwen, 1997; Wallace, Harville, Theall, Webber, Chen & Berenson, 2013; Glover, Stuber & Poland, 2006). If AL is understood as a biomarker of exposure to workplace psychosocial stressors, its utility should grow as psychosocial risk associated with the service sector and the mechanization and "robotization" of production processes become prominent.

We have identified one problematic issue in the traditional operationalization of AL. Most AL operationalizations include already unhealthy individuals and AL scores are used to predict their poor health. For example, the most used operationalization of AL has utilized a certain number of primary (endocrine and immune/inflammatory (Beckie, 2012)) and secondary (metabolic and cardiovascular (Beckie, 2012) biomarker mediators of the process of allostasis. Biomarkers have

been defined as dysregulated or out of range if their value falls in the highest risk quartile (below 25th percentile for biomarkers for which a low value implies risk or above the 75th percentile for biomarkers for which a higher value implies higher risk) (Seeman, Singer, Roew, Horwitz & McEwen, 1997). This operationalization is potentially problematic because certain people who have clinically abnormal biomarker values and/or potentially have been already classified as having a disease are often included in the high risk AL group. By doing so, three diverse subgroups of people are part of the high risk AL group. **A first "healthy" subgroup** with one or more biomarker in the high risk quartile range, but no value out of clinical range and no clinically diagnosed disease; **a second "undiagnosed" subgroup** with one or more biomarker out of clinically normal value, but not any diagnosed disease; and **a third "ill" subgroup** that already have a diagnosed disease and may have a biomarker in the high risk group. Additionally, patients receiving treatment to normalize biomarkers (for example, hypoglycemic drugs), whom could be classified in the low or high risk group depending on the level of the treated biomarker despite the fact that the "wear and tear" on that person has already evolved to the point where treatment is needed.

AL's traditional operationalization weaknesses can potentially have large impacts on the association between AL and health outcomes. If the study population contains many individuals with biomarker values out of clinically normal range, with a diagnosed disease, and/or who are taking medication to lower the value of the relevant biomarkers, the findings will represent mostly populations with high prevalence of diseases and, therefore, bad health.. In the latter case, the advantage of using AL instead of a more traditional homeostatic approach looking at out-of-range values or a traditional clinical approach regarding disease diagnoses disappears. It is possible that the some of the previously reported association between AL and health outcomes may be overestimated due to the inclusion in the high risk AL categorization of individuals with biomarker values out of a homeostatic range (and, therefore, deserving diagnosis) or already with diagnosed diseases. If that were the case, AL would not be a tool that is an early predictor of poor health; it would just be another measure of poor health.Self-reported of health (SRH) and function indicators have been excellent association with future mortality and clinical measures of health status.

Therefore, the aims of this study are: 1) To build an indicator of AL based on clinically healthy individuals within a clinically normal range in all those biomarkers utilized to build the AL indicator. 2) To estimate the association of AL as an outcome with occupation and AL as a predictor with self-rated health and function

2. Methods

2.1 Population:

The National Health Survey (NHS) of Chile included 4,956 participants, representing the entire Chilean population, who agreed to provide blood for lab tests. A sequence of exclusions due to biomarkers out of range or clinically diagnosed diseases, the sample size included 976 seemingly healthy subjects (18.4% of the initial sample) resulting in a weighted sample size of 3,205,707 Chilean adults.

2.2 Variables

2.2.1 Allostatic load

The AL scores were calculated based on how many values for each biomarker fell within the riskiest quartile (highest or lowest) for that biomarker (blood glucose, systolic and diastolic blood pressure; resting heart rate; BMI) Due to the exclusion criteria, no participant had biomarker values out of clinical range.

2.2.2 Self-Reported Indicators of Health and Function

The 2009 National Health Survey has six questions asking for self-reported health and function. For example: *in general, you would say your health is…?;*" "*How much does your current health limit your performance in moderate activities such as relocating a table, doing vacuum cleaning, or walking for one hour.* For each question, the answers implying the worst case situation ("*Bad*," "*It limits me a lot*," "*Always*," and "*Almost always*") were recoded as "1" and all others as zero. A composite scale (Self-Rated Health and Function) was created by adding the recoded answer scores.

2.2.3 Occupation

Occupation was obtained as an open response to the question "*What type of work or activity do you have or had?*" and was later coded by expert coders using the International Standard Classification of Occupations (ISCO-88) at the four-digit level (Elias, 1997). Variables using one, two, and three digits of ISCO-88 were created from the initial expert coding of four digits.

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2.3 Statistical Analysis.

Using Generalized linear mixed models, the Self-Rated Health and Function variable, which was dichotomized in none or one worst-case self-reported health or functions indicators and two or more worst-case self-reported health and function indicators. This dichotomized variable was predicted by AL score as the probability of having two or more worst case self-reported functions using Poisson distribution with log link, no random effects, robust estimation of covariance, weighted by the expansion factor for using exams, and a maximum number of 1000 iterations. Occupation ten categories predicted AL using the same statistical approach.

3. Results

3.1. Occupation predicting AL score

The occupational category "Legislators, Senior Officials and Managers" had the lowest mean AL (0.001) and were therefore set as the reference occupation category. In comparison to them, "Armed Forces" (RR=2.21, 95%, CI 1.34 -3.63); "Technicians and Associate Professionals" (RR=1.94, 95% CI 1.15-3.27); "Craft and Related Trade Workers" (RR=1.80, 95% CI 1.14-2.83); and "Plant and Machine Operators" (RR=1.71,95% CI 1.06-2.77) had significantly higher AL scores.

3.2 AL score predicting self-rated health and function

There is a clear linear unadjusted direct association between AL scores and the percentage of the weighted sample with two or more worst-case health and function self-evaluations, with consistently increased percentage of "two or more worst self-rated health and function" with every additional increase in AL score. After controlling for demographic and SES indicators each increase of one count in the AL indicator increases the probability of having two or more worst-case self-evaluations by 39% (RR=1.39, 95% CI 1.09-1.78).

4. Discussion

From the point of view of how AL was operationalized, the main distinction in this study resides in the emphasis on performing the measurements only in workers with no diagnosed diseases and with biomarkers within the clinical range. The main purpose was to exclude those cases that have such a large physiological dysregulation (in clinical range) that any correlation between the indicator of allostatic load and a health outcome might have been considered as "an association between the same variable measured in different ways." We could not find any study that identified the difficult interpretation of the AL score when it includes people in the high risk group with diseases, with biomarkers over the clinical threshold, and others with biomarkers within the normal clinical range. Given the hypothesis expressed by Karlamangla that "*even small dysregulations are expected to contribute to health risks, if they are present in multiple systems*" (Kerlamangla, Singer, McEwen, Rowe & Seeman, 2002) we purposefully narrowed our operationalization of AL to capture only those small non-clinical dysregulations and evaluate whether they were or not associated with a well-known determinant of health (occupation) and important health outcome (self-reported health and function). This study found that our AL measure was associated with both, seeming to support the quote by Karlamangla, that we can interpret biomarker variations within the clinically normal values as indicators of some sort of physiological dysregulation.

5. Conclusion

Despite having excluded people with diagnosed diseases and those with biomarkers out of clinical range, there was a significant association between occupation and AL and AL and self-reported health and function. If replicated, this finding could mean that biomarkers in clinically normal range should be considered together as a comprehensive early evaluation of wear and tear already reflected in subjective indicators of health and function, which are good predictors of future health. The clear association with occupation might represent residual confounding for uncontrolled socioeconomic status (in terms of prestige and power) and the impact of being exposed to deleterious working conditions, which regarding the concept of allostatic load might be mostly psychosocial in nature. Most studies showing associations in which AL predicts future health events, are not conclusive because those AL operationalizations include the same health events within them, predicting recursively the same variable.

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