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The Mediating Effect of Unhealthy Behaviors and Body Mass Index in the Relation Between High Physical Workload and Self-Rated Poor Health in Male Construction Workers

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Objectives: To examine the mediating role of unhealthy behaviors and body mass index (BMI) in the relation between high physical workload and self-rated health in male construction workers. **Methods:** Longitudinal data over 2010 to 2018 were used of 30,224 male construction workers in The Netherlands. Smoking, lack of physical activity, and alcohol consumption were self-reported. BMI was based on measured body weight and height. Multilevel modeling path analyses were used to determine the mediating role of unhealthy behaviors in the relation between physical workload and poor health. **Results:** A direct effect of high physical workload on poor health adjusted for unhealthy behaviors and BMI was found (odds ratio [OR] 1.49, 95% confidence interval [CI] 1.38 to 1.68). Indirect effects of the unhealthy behaviors and BMI in the relation between high physical workload and poor health were small (OR varying from 0.96 to 1.04). **Conclusion:** The pathway of high physical workload and poor health through unhealthy behaviors and BMI was not supported.

Keywords: health inequalities, lifestyle factors, low socioeconomic status, overweight, path analysis, working conditions

Health inequalities between people from higher versus lower socioeconomic position (SEP) are present worldwide and are substantial. For that reason, the World Health Organization has articulated tackling socioeconomic health inequalities to be a main priority.[1] Multiple factors have shown to contribute to the explanation of socioeconomic health inequalities, including material, psychosocial, and (lifestyle) behavioral factors.[2] Among workers, lifestyle and physical and psychosocial work factors have been identified as important determinants of inequalities in self-rated health.[3] To improve the health of lower SEP workers, knowledge about the determinants and the interplay between them is important.

High physical workload (eg, lifting, pushing, and pulling heavy loads) is particularly prevalent in blue-collar workers, who are mainly from low SEP[4] and has been shown to be associated with poorer health.[5–8] For example, a prospective study in older workers found that constant high physical work demands affect both physical and mental health negatively.[9] In addition, unhealthy behaviors are a main determinant of the poorer health status of low SEP workers. For example, a study among Dutch workers showed that those with a low SEP were more likely to have unhealthy behaviors and obesity and overweight compared with workers from a higher SEP.[10] Also, blue collar workers have shown to be at higher risk for smoking than white collar workers, with construction workers even more likely to be daily smokers than other blue collar workers.[11] In the Dutch construction sector, the prevalence of overweight and obesity, smoking, and physical inactivity is higher than in the average Dutch male population.[12] For example, 70% of the Dutch construction workers aged 40 years and over is overweight compared with 55% among the male Dutch population.[12] Thus, both high physical workload and unhealthy behavior are important determinants of a poor health status among low SEP workers, such as construction workers. However, besides being a health determinant, unhealthy behaviors may mediate the negative health effects of high physically demanding work among low SEP workers. Namely, research has shown that physically demanding work is associated with unhealthy behaviors, such as physical inactivity[13,14] and smoking.[15,16] Also, physically demanding work has been found to be associated with higher alcohol consumption.[17] We thus hypothesize that workers with a higher physical workload report a poorer health status, which is partly explained by an unhealthy lifestyle. Studies to this interrelationship are however lacking. Considering the evident disease burden of unhealthy behaviors and the existing socio-economic health inequalities, more insight into the role of unhealthy behaviors in the health effects of physical workload in a group of low SEP workers is needed. Therefore, the aim of the present study was to examine the mediating role of unhealthy behaviors in the relationship between high physical working conditions and self-rated poor general health in male construction workers, who are considered as of generally low SEP.

METHODS

Study Population and Design

All construction workers in the Netherlands were invited for a Periodical Medical Examination (PME) by the occupational health and safety services once every 4 years. Workers aged 40 years and over were invited every 2 years, and workers with heavy physically demanding jobs, such as scaffolders, were invited on a yearly basis.[12] The PME took place at the occupational health service and consisted of a questionnaire and physical examination. Data from the PME over the period 2010 until 2018 were used, since questions about lifestyle and self-rated health were introduced from

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Clinical significance: This study did not find an explanatory role of the unhealthy lifestyle behaviors in the health effect of high physical workload. Still, as both high physical workload and unhealthy behaviors are related to poor health, measures targeting work- and lifestyle factors are considered to contribute to health benefits.

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2010 onwards.[18] Participation levels for the PME were estimated to be 50% to 60% of the total construction workers population in the Netherlands. By a statement in the PME questionnaire that the data are used for research, respondents provided informed consent to use their data for scientific research. Via a trusted third party (TTP), the pseudonymized data were provided to the knowledge and advice center in the construction industry, that collects the data from employees who use the collective labor agreement for prevention care.

In the period 2010 until 2018, 76,141 construction workers aged 15 to 72 participated in one or more PMEs. For the purpose of the present study, administrative staff ($N = 24,616$) were excluded, because they are generally of intermediate or high educational level. Female construction workers were initially excluded from the analyses because of their low proportion in the sample (4%).[19] Furthermore, workers with only one measurement were excluded because of the longitudinal design of the analyses including a time lag between working conditions and self-rated health ($N = 21,162$). Workers with less than half a year or more than 7 years between the measurements ($N = 139$) were also excluded.[19] In total 30,224 male construction workers with at least two measurements were included in this study (Fig. 1). The mean follow-up duration was 2.3 years (standard deviation [SD] = 0.9) and the construction workers under study had 2.9 (SD = 0.9, range 2 to 8) PMEs on average.

Variables

Physical Workload

Exposure to physical workload was defined by two components: strenuous working postures and manual material handling, as was done previously.[19,20] Strenuous working postures were assessed by two questions to be answered on a dichotomous scale (yes/no): ''During your work, do you often have to work for a prolonged period of time in an uncomfortable position?'' and ''During your work, do you often have to work for a prolonged time in a kneeling or crouching position?'' Manual material handling was also assessed by two questions on a dichotomous scale (yes/no): ''During your work, do you often have to lift, push, or pull or carry heavy loads?'' and ''During your work, do you often have to exert great force?'' If the worker answered ''yes'' to at least one of the four questions, the worker was considered to be ''highly exposed'' to physical workload.[19]

Self-Rated Poor Health

Self-rated health was measured by means of a single item question: ''Do you feel healthy?'' (yes/no). Those who answered ''no'' were considered as having a ''poor health'' versus ''good health'' in case of ''yes.''

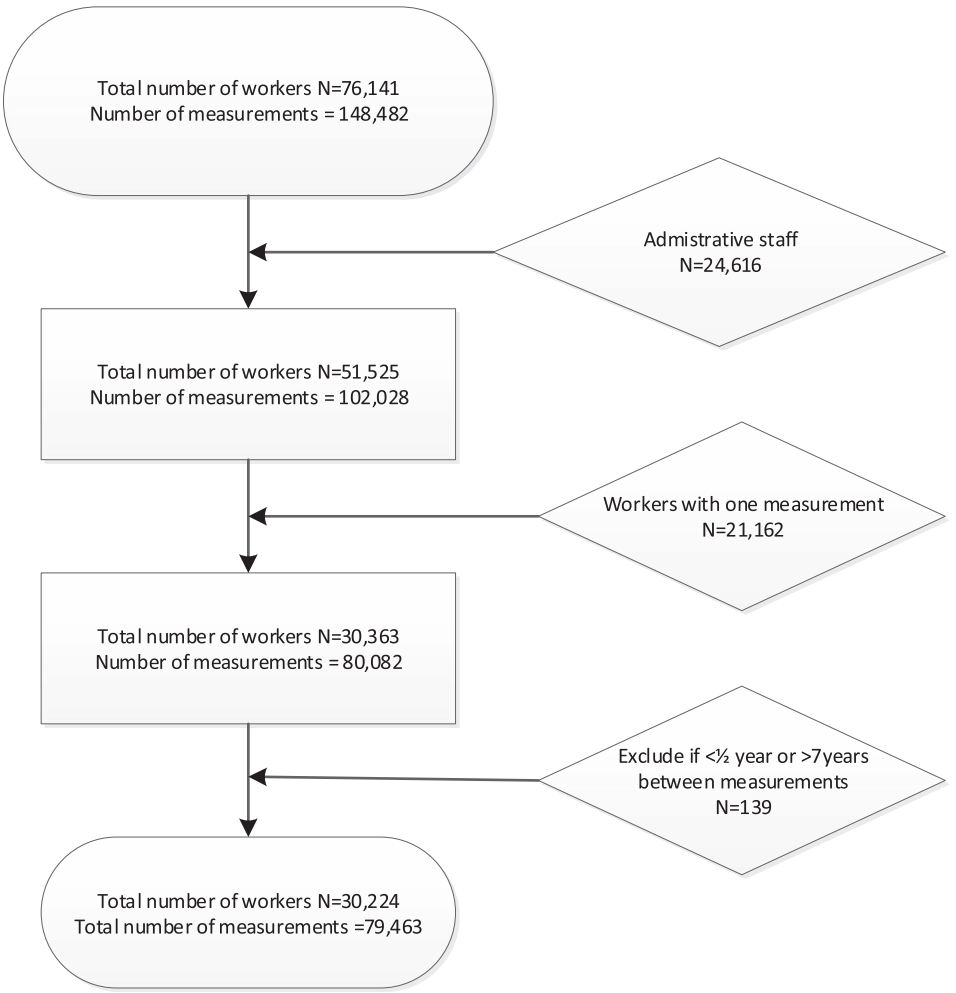

FIGURE 1. Flow chart of the study population.

Unhealthy Behaviors and Body Mass Index

Lack of physical activity was based on two questions. First, workers were asked about the days per week they usually spent on moderate intensity physical activity for at least 30 minutes. The second question referred to the frequency (in times per week) of vigorous physical activity in the past month. No distinction was made by setting, implying that physical activites could refer to both leisure time and work-related. Participants were considered insufficiently active if they indicated to be neither physically active of at least moderate intensity for 5 or more days per week nor performed vigorous intensity activities for at least 20 minutes on 3 days per week.

Workers were asked about their smoking status and were categorized into: ''non-smokers'' (never smokers and former smokers) and ''smokers.'' Alcohol consumption was based on self-reported average weekly alcohol consumption and categorized into: zero to seven glasses (recommended norm) and more than seven glasses (high alcohol consumption).[21] Additionally, as zero drinkers may be different than those who report consuming at least one glass of alcohol, alcohol consumption was also categorized into: zero glasses, one to seven glasses a week, more than seven glasses a week. Body mass index (BMI, expressed in kg/m^2) was calculated by means of body weight in kilograms divided by height squared (in meters), both measured by an occupational nurse at every PME. Participants were categorized in three BMI categories: healthy weight (18.5 to 24.9 kg/m^2), overweight (25 to 29.9 kg/m^2), and obese (more than or equal to 30 kg/m^2).[22]

Covariates

Supplemental Table 1, http://links.lww.com/JOM/A769 presents a conceptual model as to potential confounding factors. These can be divided into a host of sociodemographic factors, work-related factors, health behavior, and health variables. However, data on these potential confounding factors have not all been collected. For example, the dataset for the current study consisted of male construction workers, women, and administrative staff (of generally intermediate or high educational level) were excluded. Therefore adjustment for sex was not necessary. As to education, it appeared that 50% of the data was missing, and marital status and ethnicity were not measured. Therefore, with regard to sociodemographic factors, only adjustment for age was performed, which is in accordance with other studies.[5,6] Based on the potential confounding model and the availability of data, the inclusion of confounding factors were defined. The following factors were included as covariates: age, weekly working hours, number of years in the current job, job strain, social support, rewards, job satisfaction, and work insecurity. Job strain was measured by means of four questions, which were based on two subscales: job control (Can you decide yourself, how you do your job?, Can you influence the work speed?) and work demands (Do you often work under time pressure, Do you have a lot of work to do?). All questions used dichotomous answer categories (yes/no). Low job control was defined if workers answered ''no'' to at least one of the two questions. A worker was considered as having high job demands in case of at least one positive answer to the related two questions. High job strain was defined in case of a high demand and a low control following the job-demand-control model.[23,24] Social support was measured by means of three questions (supported by supervisor, sphere at work, sufficient time for consultation). Low support was assigned when a respondent had answered ''yes'' to at least one of the questions. Low rewards was measured by two questions (feeling appreciated, sufficient reward) and indicated when at least one of the questions was answered ''no.'' Job satisfaction and work insecurity were measured by a single question, that is, ''In general do you feel satisfied in your current job?'' (yes/no) and ''Does this job/employer offer you sufficient work security?'' (yes/no).

Statistical Analysis

Descriptive statistics were used to present baseline information on demographics, self-rated health, unhealthy behaviors, BMI, and working conditions.

The analyses for the mediating role of unhealthy behaviors and BMI in the relation between high physical workload and self-rated poor health were conducted using logistic multilevel path analysis.[25,26] Physical workload, unhealthy behaviors, and BMI were based on ''baseline'' measurement (T) and self-rated health at follow-up measurement (T + 1) (Fig. 2). A multilevel path analysis was used since the participants had at least two measurements and repeated measurements were clustered within individuals. First, the total effect (c-path) of physical workload on self-rated poor health was determined (Fig. 2.1). Figure 2.2 shows the univariable mediation model of the effects of each unhealthy behavior or BMI (a-paths and b-paths) as well as the direct effect of high physical workload on self-rated poor health (c′-path), independently of the potential mediator (ie, unhealthy behavior or BMI) and other covariates. Then, the indirect effect of each mediator was calculated as the product of the a- and b-path (a × b). All analyses were first adjusted for age and additionally for working hours, number of years in the current job, job strain, social support, rewards, job satisfaction, and work insecurity. In addition to the univariable model, a multiple mediation model including all unhealthy behaviors was performed (Fig. 2.3). In addition, a sensitivity analysis of the multiple mediation model was performed with alcohol consumption in three categories (zero glasses, one to seven glasses, more than seven glasses). Goodness of fit was determined by means of the Akaike and Bayesian information criteria (AIC and BIC). These fit statistics were determined for the univariate and multivariate mediation models, and comparison of the AIC and BIC was done between the model adjusted for age and the fully adjusted model. Descriptives were analyzed using IBM SPSS, version 24 (Armonk, NY). Path analyses were performed using Stata, version 15.1 (StataCorp LLC, TX).

RESULTS

Study Population

Of the 30,224 construction workers included in this study, 62.5% reported a high physical workload. The mean age of the respondents was 46.1 years (SD = 9.6), and they worked on average 40.5 hours (SD = 5.8) a week (Table 1). At baseline, 29.5% of the workers smoked, almost half (46.4%) of the sample was not sufficiently active, and over 43.2% of the construction workers consumed more alcohol than recommended. The average BMI of the workers was 26.6 kg/m^2 (SD = 3.4) and approximately 68% of the study sample was overweight or obese. In total, 9.0% of the construction workers reported a self-rated poor health. Among construction workers with a self-rated poor health, 53.9% were not sufficiently active and 71.8% were overweight or obese, this was 45.7% and 67.7% respectively among those with a good health. In addition, construction workers with a poor health more often reported to have a high physical workload (72.0%) compared with workers with a self-rated good health (61.5%).

Univariable Mediation Models

The total effect (c-path) of high physical workload on self-rated poor health was an OR of 1.46 (95% CI 1.32 to 1.61), adjusted for age, working hours number of years in the current job, job strain, social support, rewards, job satisfaction, and work insecurity (Table 2), indicating that workers with a high physical workload had a higher odds for a self-rated poor health than those with a low physical workload.

All relations of physical workload with each of the unhealthy behaviors (a-path) were statistically significant. Those with a higher physical workload were more likely to have a high alcohol

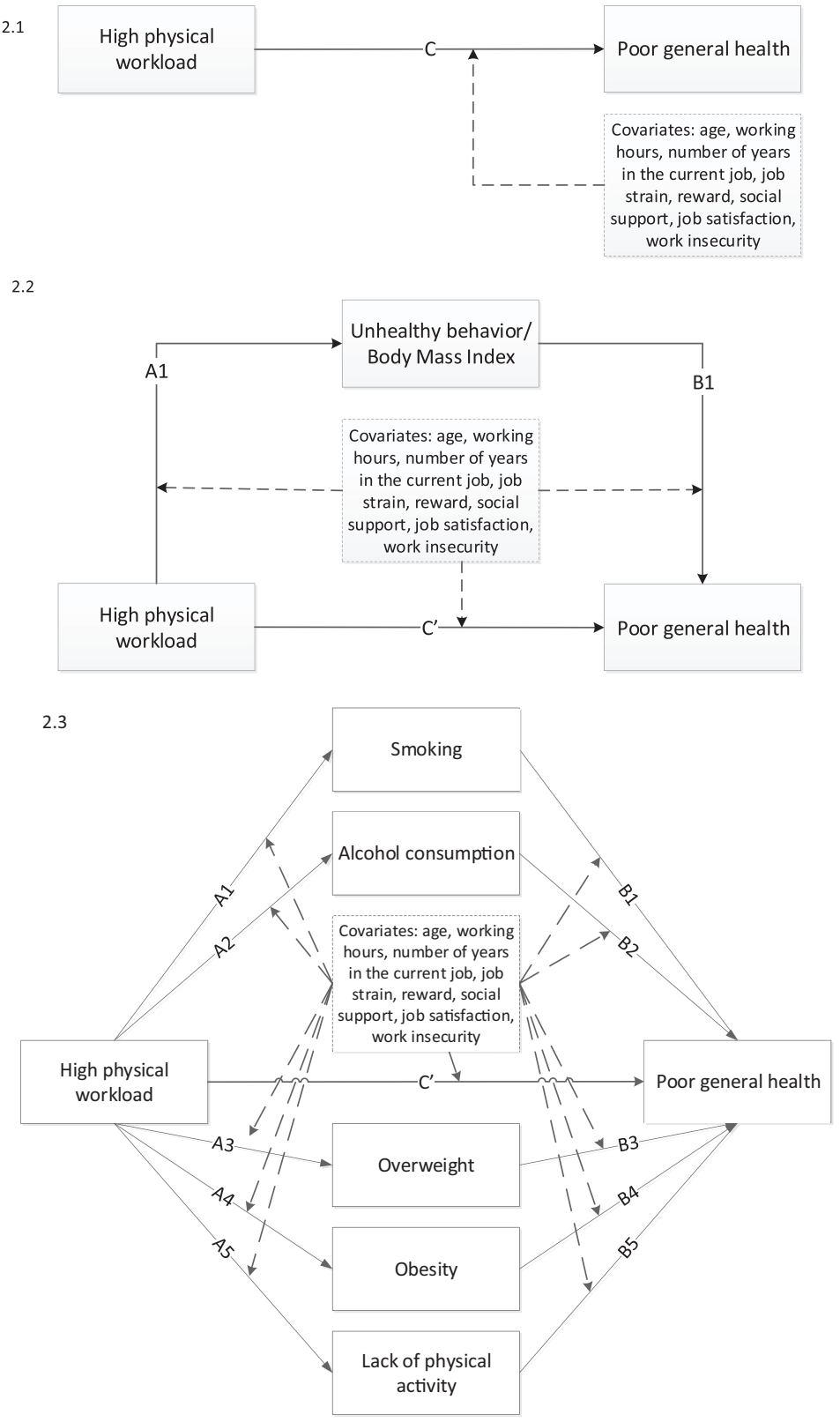

FIGURE 2. Univariable (2.2) and multiple mediation (2.3) model of the total effect of high physical workload on poor health (c, 2.1), the effects of physical workload on unhealthy behavior (a-paths), the effects of unhealthy behavior on poor health (b-paths), and the direct effect of high physical workload (c′) on poor health. All paths were adjusted for age, working hours, number of years in the current job, job strain, rewards, social support, job satisfaction, and work insecurity.

TABLE 1. Characteristics of the Study Population at Baseline

		Total $N = 30,224$*	Self-Rated Good Health $N = 27,402$ (91%)	Self-Rated Poor Health $N = 2,695$ (9%)
Age (in yrs)	Mean, SD	46.1 (9.6)	45.8 (9.6)	48.6 (8.6)
Working hours	Mean, SD	40.5 (5.8)	40.6 (5.7)	39.5 (7.3)
Years in this position	Mean, SD	19.6 (12.0)	19.4 (11.9)	21.0 (12.7)
High physical workload	*N*, %	18,690 (62.5)	16,765 (61.5)	1,925 (72.0)
Unhealthy behaviors				
Smoking	*N*, %	8,874 (29.5)	8,060 (29.5)	814 (30.3)
Lack of physical activity[a]	*N*, %	13,859 (46.4)	12,421 (45.7)	1,438 (53.9)
High alcohol consumption[b]	*N*, %	12,863 (43.2)	11,824 (43.6)	1,039 (39.1)
Overweight[c]	*N*, %	15,388 (51.2)	13,979 (51.0)	1,409 (52.3)
Obesity[c]	*N*, %	5,095 (16.9)	4,570 (16.7)	525 (19.5)
Other working conditions				
High job strain	*N*, %	5,218 (17.4)	4,586 (16.8)	632 (23.6)
Insufficient support	*N*, %	4,234 (14.1)	3,519 (12.9)	715 (26.8)
Insufficient rewards	*N*, %	12,279 (41.0)	10,868 (39.9)	1,411 (52.8)
Not satisfied with job	*N*, %	3,133 (10.4)	1,527 (5.9)	468 (17.5)
Job insecurity	*N*, %	5,684 (19.0)	4,890 (17.9)	794 (29.7)

SD, standard deviation.
[a]Lack of physical activity is defined by insufficient levels of physical activity: neither being physically active at moderate intensity for ≥5 days per week for ≥30 minutes nor performing vigorous intensity activities on 3 days per week for ≥20 minutes per session.
[b]High alcohol consumption: >7 glasses per week.
[c]Overweight: 25 to 29.9 kg/m^2, obesity: ≥30 kg/m^2.
*Numbers may not sum to the total sample size ($n = 30,224$) because of missing data on some variables.

consumption and to smoke, but were less likely to have overweight/obesity and to be physically inactive. As to the b-paths, significant effects were shown for alcohol consumption (OR 0.78; 95% CI 0.71 to 0.86), obesity (OR 1.37; 95% CI 1.19 to 1.56), smoking (OR 1.19; 95% CI 1.06 to 1.30), and lack of physical activity (OR 1.24; 95% CI 1.14 to 1.35) with self-rated poor health at follow-up (Table 2).

Direct effects (c′-path) of high physical workload on self-rated poor health were 1.49 (95% CI 1.34 to 1.64) independent of alcohol consumption, 1.48 (95% CI 1.34 to 1.63) independent of BMI, 1.46 (95% CI 1.33 to 1.61) independent of smoking, and 1.45 (95% CI 1.31 to 1.60) independent of lack of physical activity. The indirect effects shown in Table 2 indicate the extent to which the effect of high physical workload on self-rated poor health was mediated by each unhealthy behavior or BMI. Workers with a high physical workload had a 1.03 times higher odds of poor health via being a smoker compared with workers with a low physical workload. Further, those with a high physical workload had a slightly lower odds of self-rated poor health via high alcohol consumption, being more often obese and lack of physical activity. Based on the comparison between the AICs and BICs of the age adjusted (Supplemental Table 2, http://links.lww.com/JOM/A770) versus the fully adjusted univariable mediation models (Table 2), it can be seen that the fit statistics are lower in the fully adjusted model implying a better fit of the data.

Multiple Mediation Model

With all unhealthy behaviors together in the model a direct effect (c′) of high physical workload on self-rated poor health of 1.49 (95% CI 1.38 to 1.68) was shown (Table 3, Fig. 3). The effect sizes for the relation of physical workload and unhealthy behaviors

TABLE 2. Path Coefficients of the Univariable Mediation Model (Expressed as Odds Ratios) of Unhealthy Behaviors in the Relation Between High Physical Workload and Self-Rated Poor Health Among 30,224 Male Construction Workers

	c-Path (Total Effect)	c′-Path (Direct Effect)	a-Path (Physical Workload > Unhealthy Behavior)	b-Path (Unhealthy Behavior > Poor Health)	a × b (Indirect Effect)[a]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR
Total effect	1.46* (1.32–1.61)				
High alcohol consumption[b]		1.49* (1.34–1.64)	1.14* (1.11–1.18)	0.78* (0.71–0.86)	0.97
BMI[c]		1.48* (1.34–1.63)			
Overweight			0.92* (0.89–0.95)	1.07 (0.96–1.19)	0.99
Obesity			0.88* (0.84–0.92)	1.37* (1.19–1.56)	0.96
Smoking[d]		1.46*(1.33–1.61)	1.19* (1.15–1.23)	1.19* (1.06–1.30)	1.03
Lack of physical activity[e]		1.45* (1.31–1.60)	0.92* (0.89–0.94)	1.24 (1.14–1.35)	0.98

CI, confidence interval; OR, odds ratio. Analyses were all adjusted for age, working hours, number of years in the current job, job strain, rewards, social support, job satisfaction, and work insecurity.
[a]Indirect effects are calculated by taking the product of the a-paths and the b-paths (natural logarithms) (eg, $^{(a2 \times b2)} = e^{(0.111 \times -0.284)} = 0.97$).
[b]The Akaike's information criterion (AIC) and Bayesian information criterion (BIC) were 226,974.8 and 227,252.6, respectively.
[c]The AIC and BIC were 279,217.3 and 279,587.7, respectively.
[d]The AIC and BIC were 212,832.1 and 213,109.9, respectively.
[e]The AIC and BIC were 236,387.4 and 236535.7, respectively.
*$P \leq 0.05$.

TABLE 3. Path Coefficients of the Multiple Mediation Model (Expressed as Odds Ratios) of Unhealthy Behaviors in the Relation Between High Physical Workload and Self-Rated Poor Health Among 30,224 Male Construction Workers[a]

	c-Path (Total Effect)	c′-Path (Direct Effect)	a-Path (Physical Workload > Unhealthy Behavior)	b-path (unhealthy behavior > poor health)	a × b (Indirect Effect)[b]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR
Total effect	1.46* (1.32–1.61)	1.49* (1.38–1.68)			
High alcohol consumption			1.14* (1.11–1.18)	0.78* (0.71–0.85)	0.97
BMI					
Overweight			0.92* (0.89–0.95)	1.07 (0.97–1.20)	0.99
Obesity			0.88* (0.84–0.92)	1.41* (1.23–1.61)	0.96
Smoking			1.19* (1.15–1.23)	1.24* (1.12–1.38)	1.04
Lack of physical activity			0.92* (0.89–0.94)	1.22* (1.12–1.33)	0.98

CI, confidence interval; OR, odds ratio. Analyses were all adjusted for working hours, age, job strain, number of years in the current job, rewards, social support, job satisfaction, and work insecurity.

[a]The AIC and BIC of the multivariate model were 576,040.8 and 576,688.9, respectively.

[b]Indirect effects are calculated by taking the product of the a-paths and the b-paths (natural logarithms) (eg, $^{(a2 \times b2)} = e^{(0.111 \times -0.284)} = 0.97$).

*$P \leq 0.05$.

and BMI (a-paths) and for the relation of the unhealthy behaviors and BMI with poor health (b-paths) were similar to those in the separate models (Tables 2 and 3, Fig. 3). The indirect effects of the unhealthy behaviors and BMI (a × b path) on the relation between physical workload and self-rated poor health showed ORs between 0.96 and 1.04 (Table 3). As the ORs are close to 1 and because of the small effect sizes (ab/c < 0.09[27]), the data do not support the pathway through unhealthy behaviors and BMI. Results of the sensitivity analysis with the three categories of alcohol did not change the results (data not shown). Similar to the univariable mediation model, a better model fit was shown in the fully adjusted model compared with the age adjusted model (Supplemental Table 3, http://links.lww.com/JOM/A771).

DISCUSSION

This study examined the mediating role of unhealthy behaviors and BMI in the relationship between physical workload and self-rated poor health. The results showed a positive relation between high physical workload and self-rated poor health. Further, the present findings showed overall significant relations between high physical workload and unhealthy behaviors in that construction workers with a high workload were more likely to smoke and have a high alcohol consumption, but were less often overweight and obese, and insufficiently active. Smoking, obesity, and lack of physical activity were also significantly related to self-rated poor health. As to the mediation effect, we found small indirect effect sizes of the unhealthy behaviors and BMI in the relation between high physical workload and self-rated poor health. In addition, there were only small differences between the total effect and the direct effects leading to the conclusion that the pathway through unhealthy behaviors and BMI was not supported by our data and thus may not be the main pathway this relation follows.

The present study was one of the first studies to investigate the mediating role of unhealthy behaviors in the relationship

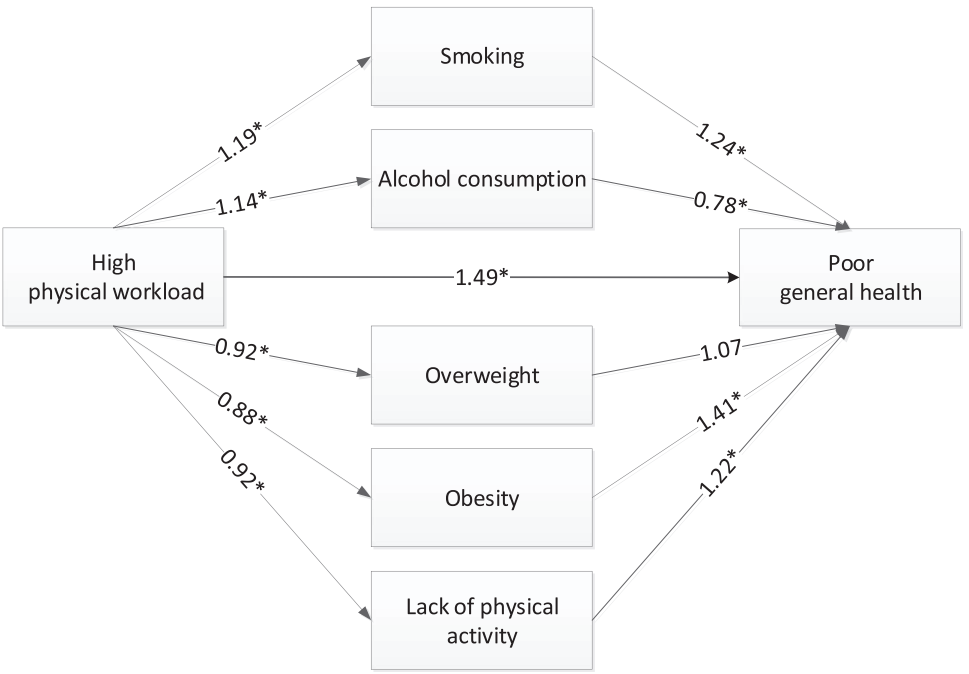

FIGURE 3. Multiple mediation model of the total effect of physical workload on self-rated health, the indirect effect of unhealthy behaviors and the direct effect of physical workload on self-rated poor health. *$P \leq 0.05$.

between physical workload and self-rated poor health. Our study to the mediation role of health behavior/BMI was based on the hypothesis that a high workload is associated with fatigue and thereby leads to sedentary and unhealthy behaviors,[28] including physical inactivity, smoking, and alcohol consumption, and consequently to a higher body weight/BMI. However, based on our data, the hypothesized behavioral mechanism was not observed, implying a direct effect of a high physical workload on poor health. Our results may also imply that other factors than health behaviors partly explain the adverse perceived health effect of high physical workload. Such other factors may, for example, involve socio-economic, cultural, health-related or work-related factors.[3] Some of these, such as age, psychosocial risk factors (eg, job strain, social support, job security), and other health behaviors were controlled for in our mediation model and did not appear to influence the effect substantially. Still, some other factors could play a confounding or explanatory role, such as socio-economic or cultural aspects, but were not measured. Future research is recommended to get more insight into the variables that influence the relation between physical workload and perceived health. With regard to educational level, there was about 50% missing data in our study population and for this reason we could not control the analyses for education. We believe that the likelihood of not including educational level as potential confounder would not have biased the results, because construction workers have almost all followed the same education and professional training. The small mediation effect sizes may also be explained by the opposite indirect effects, with for example a positive relation in the a-path and a negative relation in the b-path, leading to a total effect of about zero.[29] This occurred for alcohol consumption, overweight, obesity, and lack of physical activity. As this is one of the first studies that investigated the mediating role of unhealthy behaviors in the relationship between physical workload and self-rated poor health, more research is needed to confirm the results and to get more insight in the contribution of health behaviors underlying the poor self-rated health of low SEP workers with a high physical workload.

The finding that high physical workload was positively related to alcohol consumption and smoking is in line with previous research. For example, a longitudinal Canadian study showed that high physical exertion at work was related with heavy smoking over a 16-year period[30] and another study found physical demands to be associated with increased odds of current smoking among women.[15] Further, physical work demands, job autonomy, and social engagement were found as the three (out of 119) occupational factors to explain the majority of the variation in alcohol consumption.[17] They showed a 20% higher number of heavy drinking occasions among men working in occupations with a one standard deviation higher level of physical demands. Thus, our results that male construction workers with a high physical workload were 1.14 more likely to have a respectively high alcohol consumption compared with the lower physically demanding colleagues are affirmative.

Construction workers with high physical workload in our study were less likely to be insufficiently active, overweight, or obese. As to the link with the lack of physical activity, some previous studies showed opposite findings. For example, studies showed blue-collar male workers with a high physical workload to be more likely to be physically inactive during their leisure time[14] and those engaged in less physically demanding jobs having higher physical activity during their leisure time.[13] There may be several explanations for the opposite findings. For example, high physical workload and work-related fatigue can exhaust workers leaving less energy to perform physical activity in leisure time.[28,31]

The contrasting findings between our and previous research can also be due to differences in methodology including the measurement of physical activity. While most previous studies explicitly measured leisure time physical activity, in the present study, the questions about physical activity left room for the inclusion of leisure time as well as occupational time physical activity. As high physical workload implies high levels of occupational physical activity,[32] this may explain our result that workers with high physically demanding work being less likely to have a lack of physical activity. In this context, it may be argued that our physical activity measure is not distinct from the physical workload variable and should thus be excluded as a mediator. However, as physical workload referred to strenuous working postures and manual material handling, we believe the two variables differ in construct. This was also reflected by the differences in the baseline characteristics showing the proportion of having a high physical workload and having sufficient levels of physical activity. Moreover, a Spearman correlation coefficient of 0.023 between physical workload and physical activity was found (data not shown), which confirms that the two variables are distinct constructs. Still, the overlap between the physical workload (exposure) and physical activity measure (mediator) may be a source of bias.

Further, we found that workers with a high physical workload were less likely to be overweight and obese. Like for physical activity, mixed findings were shown in previous literature with some showing a significant link between occupational activity and overweight,[33] and others did not this.[34] Discrepancies between earlier and our results can be caused by methodological issues, such as adjustment for confounding variables. In our study, we could not adjust for possible effects of dietary consumption, which is a main factor contributing to overweight and obesity.[35] As stated earlier, future research is recommended which also includes the measurement of dietary consumption as well as other confounding variables, such as educational level and cultural aspects.

Most effects of unhealthy behaviors and BMI on general self-rated poor health (b-path) were statistically significant and, except for alcohol consumption, in line with expectations based on earlier research. Smoking, overweight, obesity, and inactivity were all related with a poorer health and thereby confirmed the evident health impact of these health behaviors.[36–39] However, in contrast with a recent systematic review in which it was concluded that ''no alcohol consumption at all improves health,''[40] we found beneficial self-rated health effects of high alcohol consumption. However, a clear explanation for our findings that the construction workers with an alcohol consumption of more than seven glasses per week perceived better health than those that drink less as well as for the better health status of workers who drink one to seven glasses compared with alcohol abstainers can not be provided.

A strength of our study is the longitudinal design with the health outcome measured at a later moment in time than the exposure and the mediating factor. In our study, the exposure and mediating factor were however measured at the same measurement, because we believed immediate effects would occur in health behaviors as a result of physical work demands rather than after 2 years. Despite we are aware of the required temporal sequence of the exposure, mediator, and outcome to ensure causality for a mediation analysis,[41] we think it is unlikely that the health behaviors had an effect on the work a construction worker does, which is generally carried out over a long period of time. Still, more research with three measurements, where the exposure is measured before the mediator, though preferably not with a long time frame in between, and the mediator measured before the outcome is recommended to verify our results. Reversed causality could however be an issue in the relation between the physical workload, health behaviors, and health. Although physical workload and mediators were measured at time t, and general health at time $t+1$, those workers who have a poor general health at time $t+1$ might also have had poor general health at time t already—and improved their health behavior. This could be an explanation for the similar exposure to unhealthy behaviors among respondents who rated their general health as

good or as poor. The use of a path analysis is considered as a strength of this study. Namely, it offers the advantage to simultaneously examine the pathways of multiple potential mediators, and thereby is considered an efficient method compared with, for example, multiple regression analysis and potential outcomes framework. However, advanced mediation methodology is emerging where limitations of more traditional mediation analysis can be better explored and used in future studies.[41] Next to the causality issue, the assumption of no unmeasured confounding or interaction of the exposure–mediator, mediator–outcome, and exposure–outcome relations could not be established in our study. The lack of adjustment for potential (unmeasured) confounding factors may have resulted in an overestimation of the findings. As this was one of the first studies to the mediating role of unhealthy behaviors in the relationship between high physical workload and poor health, more research is needed. In doing so, the current study can be replicated in the same study population of construction workers, but also in other occupational groups with a high physical workload, such as industrial workers or health care workers. Future research would also benefit from the inclusion of potential confounding variables that were not measured in the present study. Based on the model fit statistics (the AIC and BIC), it can be seen that these fit statistics were all lower in the models adjusted for all these confounders compared with the AIC and BIC in the models including adjustment for age only. However, as a limitation of the study, traditional path analysis fit indices were not available using the gsem command in STATA and therefore model fit could not adequately be studied, which may introduce bias into findings.

Another strength is the large sample size of construction workers, considered as of low SEP.[42] However, because of this study population, results can therefore not be generalized to the general or other working population, but only to male construction workers. Based on data of Statistics Netherlands over the period between 2010 until 2018, the construction industry represents a 1.4% to 2.0% of the Dutch workforce. The large sample size could also have led to small confidence intervals yielding significant effects in case of small effect sizes. Further, workers in the construction industry generally stay in the construction sector for a long period of time. As it may be assumed that those with a high physical workload exit the construction work more often than those without a high workload, we checked this in the data. Based on those analyses, we did not find differences in workers with a high versus low physical workload in the number of years working in the construction industry (data not shown) and thus do not believe time in the construction industry would have influenced the findings. As to the study population, construction workers are generally characterized by physically demanding work,[12] leaving few variation to study the effect of high physical workload. However, based on our data, more than one-third appeared not to report high physical workload, thereby enabling us to study the effect of high physical workload. Other methodological issues that need to be considered in the interpretation of the findings are the measurements. In the present study, all variables except BMI were based on self-reports, which overall have a lower validity than objective measurements. For example, self-rated alcohol consumption is mostly underestimated and physical activity levels overestimated.[43] Future research with objective measurements is thus recommended. As to the measurement of physical activity, no distinction was made by domain, so that the physical activity could involve both occupational and leisure time physical activity. Based on the opposite health effects of these two domains of physical activity,[44] this could have influenced the results towards a weakening of the mediated effect of physical inactivity. General health was also measured by self-report and using a single item question, but this simple measurement has shown to have a good validity and appeared to be powerful to identify persons at risk.[45] Moreover, the use of a single question has been used in numerous large epidemiologic studies and is a strong predictor of mortality[46] and has shown strong associations with objective measures of health status such as cerebrovascular disorders and diabetes.[47] We however used dichotomous instead of a categorical answer options, which for example range from poor to very good. Data from Statistics Netherlands show in the age group between 16 and 65 years a prevalence of ''less than good self-rated health'' ranging from 10% to 34%. The lower prevalence of 9% for self-rated poor health in our study could partly be explained by a healthy worker effect, because the information from Statistics Netherlands also includes non-employed individuals, having a higher likelihood to have a poorer health.

CONCLUSION

The findings of this study confirm that a high physical workload is related to a poor self-rated health. Workers with a high physical workload were more likely to smoke, have a high alcohol consumption, but less likely to be overweight, obese, and insufficiently active. Overall, these unhealthy behaviors were related to self-rated poor health. Based on the mediation analyses and the small effect sizes found, the pathway via unhealthy behaviors and BMI was not supported by our data, and thus may not be the main pathway the relation between high physical workload and poor perceived health follows. As this is one of the first studies to the mediating role of unhealthy behaviors underlying the relation between physical workload and poor health, more research is needed to confirm the present findings in a variety of occupational groups.

REFERENCES

1. Marmot M. Social determinants of health inequalities. *Lancet*. 2005;365:1099–1104.
2. Moor I, Spallek J, Richter M. Explaining socioeconomic inequalities in self-rated health: a systematic review of the relative contribution of material, psychosocial and behavioural factors. *J Epidemiol Community Health*. 2017;71:565–575.
3. Dieker AC, Wilhelmina IJZ, Proper KI, et al. The contribution of work and lifestyle factors to socioeconomic inequalities in self-rated health a systematic review. *Scand J Work Environ Health*. 2019;45:114–125.
4. Beenackers MA, Kamphuis CB, Giskes K, et al. Socioeconomic inequalities in occupational, leisure-time, and transport related physical activity among European adults: a systematic review. *Int J Behav Nutr Phys Act*. 2012;9:116.
5. Leijten FR, van den Heuvel SG, van der Beek AJ, Ybema JF, Robroek SJ, Burdorf A. Associations of work-related factors and work engagement with mental and physical health: a 1-year follow-up study among older workers. *J Occup Rehabil*. 2015;25:86–95.
6. Kaikkonen R, Lahelma E, Rahkonen O, Lallukka T. Physical and psychosocial working conditions as explanations for occupational class inequalities in self-rated health. *Eur J Public Health*. 2009;19:458–463.
7. Borg V, Kristensen TS. Social class and self-rated health: can the gradient be explained by differences in life style or work environment? *Soc Sci Med*. 2000;51:1019–1030.
8. Niedhammer I, Lesuffleur T, Labarthe G, Chastang JF. Role of working conditions in the explanation of occupational inequalities in work injury: findings from the national French SUMER survey. *BMC Public Health*. 2018;18:344.
9. Hiesinger K, Tophoven S. Job requirement level, work demands, and health: a prospective study among older workers. *Int Arch Occup Environ Health*. 2019;92:1139–1149.
10. Robroek SJW, Rongen A, Arts CH, Otten FWH, Burdorf A, Schuring M. Educational inequalities in exit from paid employment among Dutch workers: the influence of health, lifestyle and work. *PLoS One*. 2015;10:e0134867.
11. Ham DC, Przybeck T, Strickland JR, Luke DA, Bierut LJ, Evanoff BA. Occupation and workplace policies predict smoking behaviors: analysis of national data from the current population survey. *J Occup Environ Med*. 2011;53:1337–1345.
12. Volandis. Industry report. In: Volandis, editor; 2017.

13. Morassaei S, Smith PM. Examining the relationship between psychosocial working conditions, physical work demands, and leisure time physical activity in Canada. *J Occup Environ Med*. 2011;53:1099–1105.
14. Makinen T, Kestila L, Borodulin K, et al. Occupational class differences in leisure-time physical inactivity–contribution of past and current physical workload and other working conditions. *Scand J Work Environ Health*. 2010;36:62–70.
15. Radi S, Ostry A, Lamontagne AD. Job stress and other working conditions: relationships with smoking behaviors in a representative sample of working Australians. *Am J Ind Med*. 2007;50:584–596.
16. Miranda H, Gore R, Boyer J, Nobrega S, Punnett L. Health Behaviors and Overweight in Nursing Home Employees: Contribution of Workplace Stressors and Implications for Worksite Health Promotion; 2015: 915359 p.
17. Barnes AJ, Zimmerman FJ. Associations of occupational attributes and excessive drinking. *Soc Sci Med*. 2013;92:35–42.
18. Arbouw. Questionaire PME construction Industry; 2010.
19. Tonnon SC, Robroek SRJ, Van der Beek AJ, et al. Physical workload and obesity have synergistic effect on work ability among construction workers. *Int Arch Occup Environ Health*. 2019;92:855–864.
20. Alavinia SM, van den Berg TI, van Duivenbooden C, Elders LA, Burdorf A. Impact of work-related factors, lifestyle, and work ability on sickness absence among Dutch construction workers. *Scand J Work Environ Health*. 2009;35:325–333.
21. Health Council of the Netherlands. Alcoholic beverages. In: Health Council, editor. Background document to Guidelines for a healthy diet. The Hague, 2015.
22. WHO. Obesity: preventing and managing the global epidemic: report of a WHO consultation. WHO, Geneva; 2000.
23. Johnson JV, Hall EM. Job strain, work place social support, and cardiovascular disease: a cross-sectional study of a random sample of the Swedish working population. *Am J Public Health*. 1988;78:1336–1342.
24. Karasek JR. Job demands, job decision latitude, and mental strain: implications for job redesign. *Admin Sci Qtly*. 1979;24:285–308.
25. Preacher KJ, Zyphur MJ, Zhang Z. A general multilevel SEM framework for assessing multilevel mediation. *Psychol Methods*. 2010;15:209–233.
26. Vanderweele TJ, Vansteelandt S. Odds ratios for mediation analysis for a dichotomous outcome. *Am J Epidemiol*. 2010;172:1339–1348.
27. Cohen J. *Statistical Power Analysis for the Behavioral Sciences.* Hillsdale, NJ: Lawrence Erlbaum Associates; 1988.
28. Blafoss R, Micheletti JK, Sundstrup E, Jakobsen MD, Bay H, Andersen LL. Is fatigue after work a barrier for leisure-time physical activity? Cross-sectional study among 10,000 adults from the general working population. *Scand J Public Health*. 2019;47:383–391.
29. Mackinnon DP, Fairchild AJ. Current directions in mediation analysis. *Curr Direct Psychol Sci*. 2009;18:16.
30. Dobson KG, Gilbert-Ouimet M, Mustard CA, Smith PM. Association between dimensions of the psychosocial and physical work environment and latent smoking trajectories: a 16-year cohort study of the Canadian workforce. *Occup Environ Med*. 2018;75:814–821.
31. Rasmussen CL, Palarea-Albaladejo J, Bauman A, et al. Does physically demanding work hinder a physically active lifestyle in low socioeconomic workers? A compositional data analysis based on accelerometer data. *Int J Environ Res Public Health*. 2018;15:1306.
32. Arias OE, Caban-Martinez AJ, Umukoro PE, Okechukwu CA, Dennerlein JT. Physical activity levels at work and outside of work among commercial construction workers. *J Occup Environ Med*. 2015;57:73–78.
33. Kaleta D, Makowiec-Dabrowska T, Jegier A. Occupational and leisure-time energy expenditure and body mass index. *Int J Occup Med Environ Health*. 2007;20:9–16.
34. Singer RH, Stoutenberg M, Gellman MD, et al. Occupational physical activity and body mass index: results from the Hispanic Community Health Study/Study of Latinos. *PLoS One*. 2016;11:e0152339–e152340.
35. Schlesinger S, Neuenschwander M, Schwedhelm C, et al. Food groups and risk of overweight, obesity, and weight gain: a systematic review and dose-response meta-analysis of prospective studies. *Adv Nutr*. 2019;10:205–218.
36. Molarius A, Berglund K, Eriksson C, et al. Socioeconomic conditions, lifestyle factors, and self-rated health among men and women in Sweden. *Eur J Public Health*. 2007;17:125–133.
37. Engin A. The definition and prevalence of obesity and metabolic syndrome. *Adv Exp Med Biol*. 2017;960:1–17.
38. USDHHS UDoHaHS. *The Health Consequences Of Smoking-50 Years Of Progress: A Report of the Surgeon General.* Atlanta: Centers for Disease Control and Prevention; 2014.
39. Division of Nutrition PA, and Obesity. National Center for Chronic Disease Prevention and Health Promotion. *Physical Activity Basics Glossary of Term;* 2015.
40. Burton R, Sheron N. No level of alcohol consumption improves health. *Lancet*. 2018;392:987–988.
41. Oude Groeniger J, Burdorf A. Advancing mediation analysis in occupational health research. *Scand J Work Environ Health*. 2020;46:113–116.
42. VanderWeele TJ, Vansteelandt S. Mediation Analysis with Multiple Mediators. *Epidemiol Methods*. 2014;2:95–115.
43. Lechner L, Bolman C, Van Dijke M. Factors related to misperception of physical activity in The Netherlands and implications for health promotion programmes. *Health Promot Int*. 2006;21:104–112.
44. Holtermann A, Krause N, van der Beek AJ, Straker L. The physical activity paradox: six reasons why occupational physical activity (OPA) does not confer the cardiovascular health benefits that leisure time physical activity does. *Br J Sports Med*. 2018;52:149–150.
45. DeSalvo KB, Bloser N, Reynolds K, He J, Muntner P. Mortality prediction with a single general self-rated health question. A meta-analysis. *J Gen Intern Med*. 2006;21:267–275.
46. Huisman M, van Lenthe F, Mackenbach J. The predictive ability of self-assessed health for mortality in different educational groups. *Int J Epidemiol*. 2007;36:1207–1213.
47. Wu S, Wang R, Zhao Y, et al. The relationship between self-rated health and objective health status: a population-based study. *BMC Public Health*. 2013;13:320.

