Are long working hours associated with weight-related outcomes? A meta-analysis of observational studies

Running title: Long working hours and weight-related outcomes

Yi Zhu, MS[1], Jianxin Liu, MS[1], Heng Jiang, PhD[2,3], Tracey J Brown, PhD[4], Qingfeng Tian, PhD[5], Yudi Yang, MS[1], Chao Wang, PhD[1], Hongbin Xu, PhD[1], Junan Liu, PhD[1]*, Yong Gan, PhD[1]*, and Zuxun Lu, PhD[1]*

[1]Department of Social Medicine and Health Management, School of Public Health, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, Hubei, China

[2]Centre for Alcohol Policy Research, School of Psychology and Public Health, La Trobe University, Melbourne, Victoria, Australia

[3]Melbourne School of Population and Global Health, University of Melbourne, Melbourne, Victoria, Australia

[4]Norwich Medical School, University of East Anglia, Norwich NR4 7TJ, UK

[5]Department of Social Medicine, Zhengzhou University, Zhengzhou, China

***Correspondence to**: Professor Zuxun Lu, Department of Social Medicine and Health Management, School of Public Health, Tongji Medical College, Huazhong University of Science and Technology, No. 13 Hangkong Road, Wuhan 430030, China; E-mail: zuxunlu@yahoo.com; Telephone and fax numbers: +86-27-83693756 or Dr. Yong Gan, Department of Social Medicine and Health Management, School of Public Health, Tongji Medical College, Huazhong University of Science and Technology, No. 13 Hangkong Road, Wuhan, 430030, China; +86-27-83692392; E-mail: scswj2008@163.com; or Professor Junan Liu, Department of Social Medicine and Health Management, School of Public Health, Tongji Medical College, Huazhong University of Science and Technology, No. 13 Hangkong Road, Wuhan, 430030, China; Telephone and fax numbers: +86-27-83691782; E-mail: lja10_11@163.com

Key words: long working hours, weight-related outcomes, meta-analysis

Acknowledgement: This study was funded by Huazhong University of Science and Technology Double First-Class Funds for Humanities and Social Sciences.

Conflict of interest statement: All authors declare no conflicts of interest.

Summary

Background: The relationship between long working hours and body weight outcomes remains inconclusive, thus we conducted a meta-analysis to assess the effect of long working hours on weight-related outcomes.

Methods: PubMed and Embase databases were searched from their inception to June 2019. A random-effects model was used to assess the pooled odds ratio (OR) and corresponding confidence interval (CI). Subgroup analyses and sensitivity analyses were conducted to explore sources of heterogeneity. Publication bias was evaluated by the Begg's and Egger's tests.

Results: A total of 29 articles involving 374,863 participants were included. The pooled OR of long working hours on weight-related outcomes was 1.13 (95% CI: 1.07-1.19). In subgroup analysis stratified by definition of outcomes, the pooled ORs of long working hours on "Weight gain/ BMI increase", "BMI≥25 kg/m^2", and "BMI≥30 kg/m^2" were 1.19 (95% CI: 1.02-1.40), 1.07 (95% CI: 1.00-1.14), and 1.23 (95% CI: 1.09-1.39), respectively. We found evidence of publication bias, but correction for this bias using the trim-and-fill method did not

alter the combined OR substantially.

Conclusion: There was evidence to suggest that long working hours are associated with adverse weight-related outcomes. Preventative interventions such as improved flexibility and healthy working schedules should be established for employees.

Introduction

After the International Labour Organization (ILO) convention (C001) introduced a maximum working time of eight hours per day and forty-eight hours per week in 1919, the reduction of the legal working week has been widely adopted around the world.[1] Driven by legislation, shorter working hours have become a general trend.[2] However, approximately one-third of the world's workforce still works more than 48 hours per week.[3] The Organization for Economic Cooperation and Development (OECD) found that the largest proportion of employees were working 40 hours or more per week in most member countries.[4] Nowadays, long working hours are considered to be a key factor in contributing to weight change, especially weight gain and total body obesity as measured by body mass index (BMI).[5-8]

Obesity not only results in multiple health problems for individuals, but is also a growing public health issue worldwide. There were 39% of adults classed as overweight in 2016, and 13% with obesity according to the World Health Organization (WHO).[9] Previous studies have shown that working long hours has adverse effects on health and behavior, such as cardiovascular disease,[10-12] type 2 diabetes,[13] miscarriage,[14] mental health disorder[15, 16] and

alcohol misuse.[17] A number of epidemiological studies have explored the role of long working hours on weight-related outcomes such as weight gain, overweight, and obesity. However, the results are inconclusive and controversial.[6-8, 18-33] A previous review conducted by Solovieva *et al.*[34] found a weak association between long working hours and weight gain, but it did not use quantitative methodology to assess the pooled effect estimates. Therefore, we performed a meta-analysis to summarize the evidence on the association between long working hours and weight-related outcomes.

Methods

Search strategy

This systematic review and meta-analysis was conducted according to the Meta-analysis of Observational Studies in Epidemiology (MOOSE) guidelines.[35] Two authors (Y.Z. and J.X.L.) independently searched PubMed and Embase databases from their inception to June 2019 to identify eligible original studies. Relevant search terms are provided in the supplementary

table. Additionally, reference lists of all eligible articles were manually searched by two authors (Y.G. and J.X.L.). Any disagreements were resolved through consultation with a third investigator (Z.X.L.).

Selection criteria

Studies that met all of the following criteria were included in this review: (i) the article was published in English; (ii) the study design was cohort, case–control or cross-sectional; (iii) the study reported an association between long working hours and weight-related outcomes (i.e. weight gain, BMI increase, overweight and/or obesity); (iv) the study provided odds ratios (ORs) or risk ratios with 95% confidence intervals (CIs) or offered sufficient data to calculate them. Letters, reviews, clinical trials, animal studies, commentaries or editorials were excluded.

In this study, weight-related outcomes were: weight gain, BMI increase, overweight and/or obesity. Overweight/obesity was defined using the WHO[36] criteria of BMI greater than or equal to 25 kg/m^2. Weight gain or BMI increase was defined as body weight having increased during the period of investigation. Based on the criteria of the ILO,[37] normal weekly working

hours were defined as working for 35-40 hours per week, a standard which has been extensively adopted in many countries. Therefore, we considered ‘long working hours’ to be working beyond this standard.

Data extraction

We extracted the following characteristics from included studies: name of first author, year of publication, country, characteristics of participants, definition of outcomes, exposure group and reference group, number of participants, and covariates adjusted for in the statistical analysis.

Quality appraisal

The National Institutes of Health’s Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies was used to evaluate quality of studies.[38] The scale included 14 items and each item scored one point if achieved. Each item had three response options including ‘yes’, ‘no’ and ‘other’. ‘Other’ had three meanings including ‘cannot determine’, ‘not applicable’, and ‘not reported’. All studies were independently appraised by two authors (Y.Z.

and J.X.L.), and inter-observer agreement (κ) was 0.872. Disagreements on quality assessment were resolved by discussion with the third author (Z.X.L.).

Statistical analyses

In this meta-analysis, seven studies[6, 18, 21, 24, 27, 33, 39] provided information on working hours that were not on a weekly basis, so we converted them as Kazuhiro *et al*.[16] did: working hours per day were multiplied by 5; working hours per month were divided by 4; and overtime per month was divided by 4 and then 40 was added to this result. Importantly, in this primary analysis, we combined the estimates using a fixed-effects model to obtain an overall estimate in the primary analysis, if studies (i) reported ORs for weight-related outcomes in several categories of long working hours; (ii) reported ORs of weight-related outcomes for long working hours by gender; (iii) reported ORs of weight-related outcomes for long working hours at different activity levels; (iv) reported ORs of weight-related outcomes for long working hours by type of occupation.[40]

A random-effects model was used to pool the effect estimates. We used I^2 statistic to assess heterogeneity across studies. Subgroup analyses were conducted to explore the potential

sources of heterogeneity, and were stratified by gender, location, occupation type, cut-off point of long working hours (>48 hrs/wk), quality score, study design, and definition of weight-related outcomes. We also conducted sensitivity analyses to examine the robustness of pooled risk estimates. The Begg's test and Egger's test were used to evaluate publication bias. All statistics in this study were performed using STATA.11.0. All tests were two-sided and a *P* value <0.05 was considered to be statistically significant.

Results

Literature search

Figure 1 shows the process of study selection. Initially, we reviewed 10,301 articles, with 4,890 from PubMed, and 5,411 from Embase. After removing duplicates and screening by title and abstract, there were 80 articles remaining for full text assessment. Of these, four articles were interventional or experimental trials; 45 articles were excluded because the association of interest had not been evaluated; two articles reported results from the same

study population. Finally, 29 eligible articles (21 cross-sectional studies and 8 cohort studies) were included in this meta-analysis.

Characteristics and quality of the included studies

Table 1 presents the basic characteristics of the 29 studies. Studies were published between 2006 and 2018. Data were available from 374,863 employees. The studies were from the following countries such as the United States,[6, 7, 22, 23, 26, 41] South Korea,[8, 28] Japan,[27, 29, 32, 33, 39, 42] Brazil,[25, 30] Italy,[19] Finland,[29, 43-46] the United Kingdom,[29, 46] Saudi Arabia,[18] Serbia,[20] Australia,[24, 31, 47, 48] Denmark,[46] Sweden,[46] and Canada.[49] Six studies[8, 18, 20, 22, 26, 47] reported results for females, two[6, 27] reported results for males, eleven studies[7, 19, 21, 23, 24, 31, 32, 41, 42, 46, 48] reported results for both males and females, and the remaining ten studies[25, 28-30, 33, 39, 43-45, 49] reported results for males and females separately. Twenty-three studies[7, 8, 18, 19, 21-24, 28, 29, 31-33, 39, 41-49] were conducted on populations with mixed occupations. Two studies[25, 26] focused on nurses, and one[20] focused on physicians. Of the four remaining studies, three[27, 29, 30] were conducted on civil servants, and one[6] focused on truck drivers. The majority of studies adjusted for confounders but five studies[18, 27, 30, 39, 47] did not. Table 2 reports the quality scores

of the 29 studies which ranged from 6 to 12 (out of 14 points). The average score of all articles was 8.3 points.

Association between long working hours and weight-related outcomes

A total of 29 articles were included in this meta-analysis. Figure 2 shows the pooled effect size for weight-related outcomes in relation to long working hours. The pooled OR was 1.13 (95% CI: 1.07-1.19, I^2 = 75.7%, P < 0.001) for the association between long working hours and weight-related outcomes.

Subgroup analyses

Subgroup analyses were used to identify the potential sources of heterogeneity and examine the stability of the relationship between long working hours and weight-related outcomes across different study categories. Table 3 shows the subgroup analyses stratified by gender, geographical location, occupation, cut-off point of long working hours, definition of weight-related outcomes, study design, and quality scores. All subgroups had positive associations between long working hours and adverse weight-related outcomes.

Regarding type of occupation, studies that focused on civil servants and healthcare workers, showed similar risks of adverse weight-related outcomes compared with those focused on populations with mixed occupations. There were no significant differences between different geographical locations.

The cut-off point of 48 hours per week, the maximum working time per week set by the ILO (C001), was selected as the upper threshold of long working hours. To further investigate whether there were possible dose-response associations between long working hours and weight-related outcomes, we performed meta-analysis stratified by cut-off point of long working hours. The pooled effect among those who worked more than 48 hours per week was similar to those who worked less than or equal to 48 hours per week.

Sensitivity analyses

In order to examine the robustness of primary results, sensitivity analyses were conducted. A similar result (OR = 1.13, 95% CI: 1.04-1.22) was found when we only pooled the results of studies whose participants excluded part-time workers (less than 35 hours per week).[8, 21, 23, 24, 28, 32, 46-49] When excluding five studies[18, 27, 30, 39, 47] that did not adjust for any confounding

factors, the summarized estimates did not substantially alter (OR = 1.15, 95% CI: 1.08-1.23). After omitting each study in turn, the pooled OR was persistent with a narrow range from 1.12 (95% CI: 1.06-1.17) to 1.14 (95% CI: 1.08-1.21). The sensitivity analyses showed our findings were stable.

Publication bias

Visual inspection of the funnel plot showed asymmetry (Figure 3). The Begg's test ($P = 0.035$) and Egger's test ($P < 0.001$) suggested that there existed significant evidence of potential publication bias. Using the trim-and-fill method to assess the impact of any potential publication bias, we found that seven potentially missing studies would be needed to obtain funnel plot symmetry for long working hours (Figure 4). The correct OR using the trim-and-fill method was 1.09 (95% CI: 1.03-1.16; random-effects model, $P = 0.005$). Correction for potential publication bias did not materially alter the pooled OR.

Discussion

To the best of our knowledge, this is the first meta-analysis to evaluate the association between long working hours and various weight-related outcomes. This meta-analysis included 29 studies involving 374,863 participants. Evidence from the included studies suggests that long working hours may be a risk factor for adverse weight-related outcomes.

The underlying mechanism might be changes in lifestyle factors including: dietary pattern, sleep time and physical activity. Firstly, it has been suggested that long working hours are positively linked to poor dietary behaviors, including skipping breakfast, eating out, eating instant food, overeating, and fast eating.[50] These unhealthy eating habits are recognized as factors in the development of weight gain and obesity.[51] Secondly, it is possible that working long hours limits physical activity, resulting in fat accumulation.[23] Finally, observational studies have shown that long working hours are significantly associated with sleep deprivation.[52-55] During sleep several hormones such as leptin and ghrelin which regulate appetite are secreted.[56] Sleep reduction or deprivation could alter levels of leptin and ghrelin, increase appetite and cause a subsequent increase in food intake.[57, 58] The disruption to

metabolism and energy balance would in turn contribute to obesity.[59] Stress might be another factor mediating the effect of long working hours on weight gain and obesity.[60] Under chronic stress, the hypothalamic-pituitary-adrenal (HPA) axis, which plays a key role in the regulation of energy homeostasis and feeding behavior, might be disrupted,[28] adversely affecting energy homeostasis and food intake, reducing lean body mass and increasing production of adipose tissue.[8, 61, 62]

Subgroup analysis showed that similar positive associations were found in both male and female employees who worked long hours. However, a previous systematic review conducted by Solovieva *et al*.[34] indicated that long working hours had an effect on weight gain, especially among males. One possible explanation for the different outcome is changes in the labor market.[25] An increasing number of females have entered the labor market in most OECD member countries.[63] Compared with male employees, female employees are more likely to need to balance multiple work obligations together with family responsibilities such as child rearing and caregiving.[64-66] Women may have less time to access healthcare services, in addition to less time for healthier lifestyle behaviours such as preparing healthy food and

physical activity, which may lead to poorer health outcomes.[67] In 2019, a report published from the ILO suggested that employers should consider how to better manage the demands of balancing work and family life of employees, especially for female employees.[3] A good work-life balance is central to employee's effectiveness and satisfaction, and may eventually improve employee health and wellbeing.

There is a growing awareness that working long hours could be harmful to health and legislation to limit work time has been implemented in many organizations and countries, however overtime work cannot be fully avoided.[12] For example, employers increasingly offer flexible work-time arrangements,[68, 69] and time of work at home was hard to estimate. We did not investigate whether these individuals worked beyond the standard work time. Hence, further studies examining the relationships between flexible working schedules and employees' health are needed.

Weight gain and obesity are growing public health problems, and our study provides possible evidence of an association between long working hours and adverse weight-related outcomes. We suggest that employees who work long hours should pay more attention to

body weight change.

Study strengths and limitations

Our study has several advantages. This meta-analysis fills an important research gap by comparing long working hours with weight-related outcomes. Subgroup analyses and sensitivity analyses indicated that our findings were reliable and robust. Our study also had some limitations. Firstly, most articles (21/29) included in our review were cross-sectional in design which limited our ability to prove causality between long working hours and weight-related outcomes. More prospective cohort studies with larger samples would be beneficial to future research. Secondly, the definition of long working hours and the reference cut-off points varied across included studies. It was difficult for us to identify a scientific cut-off point of long working time that led to weight-related outcomes. A consistent definition of long working hours is needed. Moreover, we recommend that future studies use a standard work time of 35-40 hours per week as a reference for normal working hours, to enable more precise comparisons across studies. Thirdly, adjustment for confounding factors differed across studies which might influence findings; thus, we used the multivariable-adjusted OR

and its 95% CI for each included study and recommend this is used in future meta-analysis.

Conclusion

This meta-analysis suggests that there are possible associations between long working hours and adverse weight-related outcomes. Given the worldwide increasing prevalence of obesity and the potential negative effect of long working hours, it is important to focus on the health of employees who work longer hours.

Author Contributions

Y.Z., Y.G., and Z.X.L. conceived the study. J.X.L. and Y.Z. searched the databases and checked them according to the eligible criteria and exclusion criteria. C.W. and Y.G. helped develop search strategies. Y.D.Y. and H.B.X. did data extraction, and Y.Z. and J.X.L. did quality assessment. Y.Z., J.X.L. and Y.G. analyzed the data. J.A.L. and Z.X.L. gave advice on meta-analysis methodology. Y.Z. wrote the draft of the paper. Y.Z., J.X.L., Y.D.Y, H. J.,

T.J.B., Q.F.T, C.W., H.B.X., J.A.L., Y.G., and Z.X.L contributed to reviewing, or revising the paper. All authors read and approved the final manuscript. J.A.L., Y.G., and Z.X.L. are the guarantors of this work and, as such, had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

References

1. The International Labour Office. Wages and working hours in the textiles, clothing, leather and footwear industries. Geneva: ILO; 2014. [WWW document]. URL https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/publication/wcms_300463.pdf (accessed 20 December 2018).

2. Cygan-Rehm K, Wunder C. Do working hours affect health? Evidence from statutory workweek regulations in Germany. *Cesifo Working Paper*. 2018.

3. The International Labour Office. Safety and Health at the heart of the Future of Work: Building on 100 years of experience. Geneva: ILO; 2019. [WWW document]. URL https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/wcms_686645.pdf (accessed 5 May 2019).

4. The Organization for Economic Co-operation and Development. Hours worked: average annual hours actually worked. [WWW document]. URL https://www.oecd-ilibrary.org/employment/data/hours-worked/average-annual-hours-actually-

worked_data-00303-en (accessed 5 January 2019).

5. Fang L, Hsiao LP, Fang SH, Chen BC. The associations with work stress, social support and overweight/obesity among hospital nurses: A cross-sectional study. *Contemp Nurse*. 2018;54(2):182-194.

6. Lemke MK, Hege A, Perko M, Sonmez S, Apostolopoulos Y. Work patterns, sleeping hours and excess weight in commercial drivers. *Occup Med (Lond).* 2015;65(9):725-731.

7. Park S, Pan L, Lankford T. Relationship between employment characteristics and obesity among employed U.S. adults. *Am J Health Promot*. 2014;28(6):389-396.

8. Yoon CG, Kang MY, Bae KJ, Yoon JH. Do Working Hours and Type of Work Affect Obesity in South Korean Female Workers? Analysis of the Korean Community Health Survey. *J Womens Health (Larchmt).* 2016;25(2):173-180.

9. World Health Organization. Obesity and overweight. Geneva: WHO; 2018. [WWW document]. URL http://www.who.int/mediacentre/factsheets/fs311/en/ (accessed 10 January 2019).

10. Kivimaki M, Jokela M, Nyberg ST, et al. Long working hours and risk of coronary heart disease and stroke: a systematic review and meta-analysis of published and unpublished data for 603 838 individuals. *Lancet*. 2015;386(10005):1739-1746.

11. Virtanen M, Heikkila K, Jokela M, et al. Long working hours and coronary heart disease: a systematic review and meta-analysis. *Am J Epidemiol.* 2012;176(7):586-596.

12. Virtanen M, Kivimaki M. Long Working Hours and Risk of Cardiovascular Disease. *Curr Cardiol Rep*. 2018;20(11).

13. Kivimaki M, Virtanen M, Kawachi I, et al. Long working hours, socioeconomic status, and the risk of incident type 2 diabetes: a meta-analysis of published and unpublished data from 222 120 individuals. *Lancet Diabetes Endocrinol.* 2015;3(1):27-34.

14. Bonde JP, Jorgensen KT, Bonzini M, Palmer KT. Miscarriage and occupational activity: a systematic review and meta-analysis regarding shift work, working hours, lifting, standing, and physical workload. *Scand J Work Env Hea*. 2013;39(4):325-334.

15. Virtanen M, Jokela M, Madsen IEH, et al. Long working hours and depressive symptoms:

systematic review and meta-analysis of published studies and unpublished individual participant data. *Scand J Work Env Hea*. 2018;44(3):239-250.

16. Watanabe K, Imamura K, Kawakami N. Working hours and the onset of depressive disorder: a systematic review and meta-analysis. *Occup Environ Med*. 2016;73(12):877-884.

17. Virtanen M, Jokela M, Nyberg ST, et al. Long working hours and alcohol use: systematic review and meta-analysis of published studies and unpublished individual participant data. *BMJ.* 2015;350.

18. Albawardi NM, Jradi H, Al-Hazzaa HM. Levels and correlates of physical activity, inactivity and body mass index among Saudi women working in office jobs in Riyadh city. *BMC Womens Health*. 2016;16:33.

19. Barbadoro P, Ponzio E, Chiatti CJ, Di Stanislao F, D'Errico MM, Prospero E. New market labor and obesity: A nation-wide Italian cross-sectional study. *Int J Occup Med Environ Health.* 2016;29(6):903-914.

20. Belkic K, Nedic O. Workplace stressors and lifestyle-related cancer risk factors among

female physicians: Assessment using the Occupational Stress Index. *J Occup Health.* 2007;49(1):61-71.

21. Bushnell PT, Colombi A, Caruso CC, Tak S. Work Schedules and Health Behavior Outcomes at a Large Manufacturer. *Ind Health*. 2010;48(4):395-405.

22. Choi B, Schnall PL, Yang H, et al. Sedentary work, low physical job demand, and obesity in US workers. *Am J Ind Med.* 2010;53(11):1088-1101.

23. Cook MA, Gazmararian J. The association between long work hours and leisure-time physical activity and obesity. *Prev Med Rep.* 2018;10:271-277.

24. Di Milia L, Mummery K. The Association between Job Related Factors, Short Sleep and Obesity. *Ind Health*. 2009;47(4):363-368.

25. Fernandes JD, Portela LF, Rotenberg L, Griep RH. Working hours and health behaviour among nurses at public hospitals. *Rev Lat-Am Enferm*. 2013;21(5):1104-1111.

26. Han K, Trinkoff AM, Storr CL, Geiger-Brown J. Job stress and work schedules in relation to nurse obesity. *J Nurs Adm.* 2011;41(11):488-495.

27. Itani O, Kaneita Y, Ikeda M, Kondo S, Murata A, Ohida T. Associations of work hours and actual availability of weekly rest days with cardiovascular risk factors. *J Occup Health.* 2013;55(1):11-20.

28. Jang TW, Kim HR, Lee HE, Myong JP, Koo JW. Long Work Hours and Obesity in Korean Adult Workers. *J Occup Health.* 2013;55(5):359-366.

29. Lallukka T, Lahelma E, Rahkonen O, et al. Associations of job strain and working overtime with adverse health behaviors and obesity: evidence from the Whitehall II Study, Helsinki Health Study, and the Japanese Civil Servants Study. *Soc Sci Med.* 2008;66(8):1681-1698.

30. Pinto KA, Griep RH, Rotenberg L, Almeida MCC, Barreto RS, Aquino EML. Gender, time use and overweight and obesity in adults: Results of the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil). *PloS ONE*. 2018;13(3):e0194190.

31. Proper KI, Cerin E, Brown WJ, Owen N. Sitting time and socio-economic differences in overweight and obesity. *Int J Obes (Lond).* 2007;31(1):169-176.

32. Tsuboya T, Aida J, Osaka K, Kawachi I. Working Overtime and Risk Factors for Coronary Heart Disease: A Propensity Score Analysis Based in the J-SHINE (Japanese Study of Stratification, Health, Income, and Neighborhood) Study. *Am J Ind Med.* 2015;58(2):229-237.

33. Watari M, Uetani M, Suwazono Y, Kobayashi E, Kinouchi N, Nogawa K. A longitudinal study of the influence of smoking on the onset of obesity at a telecommunications company in Japan. *Prev Med.* 2006;43(2):107-112.

34. Solovieva S, Lallukka T, Virtanen M, Viikari-Juntura E. Psychosocial factors at work, long work hours, and obesity: a systematic review. *Scand J Work Env Hea*. 2013;39(3):241-258.

35. Stroup DF, Berlin JA, Morton SC, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis of Observational Studies in Epidemiology (MOOSE) group. *JAMA.* 2000;283(15):2008-2012.

36. World Health Organization. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. *World Health Organ Tech Rep Ser.* 1995;854:1–452.

37. The International Labour Office. Hours of work: from fixed to flexible? Geneva: ILO; 2005. [WWW document]. URL http://www.ilo.org/public/english/standards/relm/ilc/ilc93/pdf/rep-iii-1b.pdf (accessed 5 December 2018).

38. National Heart, Lung, and Blood Institute. Quality assessment tool for observational cohort and cross-sectional studies. Bethesda: National Institutes of Health, Department of Health and Human Services; 2014.

39. Uchiyama S, Kurasawa T, Sekizawa T, Nakatsuka H. Job strain and risk of cardiovascular events in treated hypertensive Japanese workers: hypertension follow-up group study. *J Occup Health.* 2005;47(2):102-111.

40. Hamling J, Lee P, Weitkunat R, Ambühl M. Facilitating meta-analyses by deriving relative effect and precision estimates for alternative comparisons from a set of estimates presented by exposure level or disease category. *Stat Med.* 2010;27(7):954-970.

41. Mercan MA. A research note on the relationship between long working hours and weight

gain for older workers in the United States. *Res Aging.* 2014;36(5):557-567.

42. Kuwahara K, Imai T, Nishihara A, et al. Overtime work and prevalence of diabetes in Japanese employees: Japan epidemiology collaboration on occupational health study. *PloS ONE*. 2014;9(5):e95732.

43. Roos E, Lallukka T, Rahkonen O, Lahelma E, Laaksonen M. Working conditions and major weight gain-a prospective cohort study. *Arch Environ Occup Health.* 2013;68(3):166-172.

44. Lallukka T, Sarlio-Lahteenkorva S, Kaila-Kangas L, Pitkaniemi J, Luukkonen R, Leino-Arjas P. Working conditions and weight gain: a 28-year follow-up study of industrial employees. *Eur J Epidemiol.* 2008;23(4):303-310.

45. Lallukka T, Laaksonen M, Martikainen P, Sarlio-Lahteenkorva S, Lahelma E. Psychosocial working conditions and weight gain among employees. *Int J Obes (Lond).* 2005;29(8):909-915.

46. Kivimaki M, Nyberg ST, Batty GD, et al. Long working hours as a risk factor for atrial

fibrillation: a multi-cohort study. *Eur Heart J*. 2017;38(34):2621-2628.

47. Au N, Hauck K, Hollingsworth B. Employment, work hours and weight gain among middle-aged women. *Int J Obes (Lond).* 2013;37(5):718-724.

48. Magee CA, Caputi P, Stefanic N, Iverson DC. Occupational factors associated with 4-year weight gain in Australian adults. *J Occup Environ Med.* 2010;52(10):977-981.

49. Shields M. Long working hours and health. *Health Rep.* 1999;11(2):33-48(Eng); 37-55(Fre).

50. Tanaka R, Tsuji M, Kusuhara K, Kawamoto T, Japan E, Children's Study G. Association between time-related work factors and dietary behaviors: results from the Japan Environment and Children's Study (JECS). *Environ Health Prev Med.* 2018;23(1):62.

51. Heerman WJ, Jackson N, Hargreaves M, et al. Clusters of Healthy and Unhealthy Eating Behaviors Are Associated With Body Mass Index Among Adults. *J Nutr Educ Behav*. 2017;49(5):415-+.

52. Nakashima M, Morikawa Y, Sakurai M, et al. Association between long working hours

and sleep problems in white-collar workers. *J Sleep Res*. 2011;20(1):110-116.

53. Sekine M, Chandola T, Martikainen P, Marmot M, Kagamimori S. Work and family characteristics as determinants of socioeconomic and sex inequalities in sleep: The Japanese civil servants study. *Sleep*. 2006;29(2):206-216.

54. Virtanen M, Ferrie JE, Gimeno D, et al. Long Working Hours and Sleep Disturbances: The Whitehall II Prospective Cohort Study. *Sleep*. 2009;32(6):737-745.

55. Afonso P, Fonseca M, Pires JF. Impact of working hours on sleep and mental health. *Occup Med (Lond).* 2017;67(5):377-382.

56. Knutson KL, Spiegel K, Penev P, Van Cauter E. The metabolic consequences of sleep deprivation. *Sleep Med Rev*. 2007;11(3):163-178.

57. Brondel L, Romer MA, Nougues PM, Touyarou P, Davenne D. Acute partial sleep deprivation increases food intake in healthy men. *Am J Clin Nutr*. 2010;91(6):1550-1559.

58. Taheri S, Lin L, Austin D, Young T, Mignot E. Short sleep duration is associated with reduced leptin, elevated ghrelin, and increased body mass index. *Plos Med*.

2004;1(3):210-217.

59. Bayon V, Leger D, Gomez-Merino D, Vecchierini MF, Chennaoui M. Sleep debt and obesity. *Ann Med.* 2014;46(5):264-272.

60. Spurgeon A, Harrington JM, Cooper CL. Health and safety problems associated with long working hours: A review of the current position. *Occup Environ Med*. 1997;54(6):367-375.

61. McEwen BS. Physiology and neurobiology of stress and adaptation: Central role of the brain. *Physiol Rev*. 2007;87(3):873-904.

62. Sinha R, Jastreboff AM. Stress as a Common Risk Factor for Obesity and Addiction. *Biol Psychiat*. 2013;73(9):827-835.

63. Jaumotte F. Labour Force Participation of Women: Empirical Evidence on The Role of Policy and Other Determinants in OECD Countries. *Oecd Economic Studies*. 2003;2003(2):51-108.

64. Blau FD, Kahn LM. Female Labor Supply: Why Is the United States Falling Behind? *Am Econ Rev.* 2013;103(3):251-256.

65. Craig L, Mullan K. Parenthood, Gender and Work-Family Time in the United States, Australia, Italy, France, and Denmark. *J Marriage Fam*. 2010;72(5):1344-1361.

66. Otterbach S, Tavener M, Forder P, Powers J, Loxton D, Byles J. The effect of motherhood and work on women's time pressure: A cohort analysis using the Australian Longitudinal Study on Women's Health. *Scand J Work Env Hea*. 2016;42(6):500-509.

67. Strazdins L, Broom DH, Banwell C, Mcdonald T, Skeat H. Time limits? Reflecting and responding to time barriers for healthy, active living in Australia. *Health Promot Int*. 2011;26(1):46-54.

68. Beckers DGJ, Kompier MAJ, Kecklund G, Harma M. Worktime control: theoretical conceptualization, current empirical knowledge, and research agenda. *Scand J Work Env Hea*. 2012;38(4):291-297.

69. Leineweber C, Kecklund G, Lindfors P, Hanson LLM. Change in Work-Time Control and Work-Home Interference Among Swedish Working Men and Women: Findings from the SLOSH Cohort Study. *Int J Behav Med*. 2016;23(6):670-678.

Tables and Figure legends

Table 1. Characteristics of studies included in the meta-analysis of long working hours in relation to weight-related outcomes

Table 2. Quality assessment of included studies

Table 3. Subgroup analyses of the effect of long working hours on weight-related outcomes

Figure 1.A process of study selection

Figure 2. Pooled random-effects OR and 95% CI for the effect of long working hours on weight-related outcomes

Figure 3. Funnel plot for studies of weight-related outcomes in relation to overtime work

Figure 4. Filled funnel plot for studies of weight-related outcomes in relation to overtime work