Title: Working (longer than) 9 to 5: Are there cardiometabolic health risks for young Australian workers who report longer than 38 hour working weeks?

Amy C Reynolds [1*]

Romola S Bucks [2,]

Jessica L Paterson [1]

Sally A Ferguson [1]

Trevor A Mori [3]

Nigel McArdle [4,5]

Leon Straker [5]

Lawrence J Beilin [3]

Peter R Eastwood [4,5]

[1] Appleton Institute, CQUniversity Australia, Wayville, Australia

[2] School of Psychological Science, University of Western Australia, Perth, Australia

[3] Medical School. Royal Perth Hospital Unit. University of Western Australia, Perth. Australia 6000

[4] Centre for Sleep Science, School of Human Sciences, University of Western Australia, Australia

[5] West Australian Sleep Disorders Research Institute, Department of Pulmonary Physiology and Sleep Medicine, Sir Charles Gairdner Hospital

[6] School of Physiotherapy and Exercise Science, Curtin University, Perth, Australia

***** Correspondence: a.reynolds@cqu.edu.au; Tel.: +61-407-525-047; The Appleton Institute, CQUniversity Australia, 44 Greenhill Road, Wayville SA 5034

Acknowledgments

The authors gratefully acknowledge the ongoing input of the Raine Study participants and their families, the Raine Study Team for ongoing co-ordination of cohort follow-ups and data collection, and the National Health and Medical Research Council (NHMRC) for funding contributed to this research for the past 25 years. The core management of the Raine Study is funded by The University of Western Australia (UWA), Curtin University, The Telethon Kids Institute, Raine Medical Research Foundation, UWA Faculty of Medicine, Dentistry and Health Sciences, Women's and Infant's Research Foundation and Edith Cowan University. The 22 year Raine Study follow-up was funded by National Health and Medical Research Council of Australia project grants (1027449 (Eastwood et al), 1044840 (Straker et al) and 1021855 (Hall et al)), Future Health WA (G06302, Eastwood et al) and Safe Work Australia.

Author Contributions

PRE and LS are the Director and Scientific Director, respectively, of the Raine Study and have ongoing involvement in study design. TAM, NM, LJB, RSB are all involved in study design and data collection. All authors contributed to data analysis approaches and techniques. ACR wrote the article with RB, JLP and SAF, and all authors provided meaningful revision and feedback on the manuscript.

Abstract:

Purpose: The average Australian working week in middle-aged and older workers exceeds government recommendations. Long working weeks are associated with poor health outcomes; however, the relationship between long working weeks and health in young Australian workers is unknown.

Methods: Data were drawn from the 22 year follow-up of the Western Australian Pregnancy Cohort (Raine) Study in Perth, Western Australia. Information was available from 873 young adults about working hours per week, shift work and sleep duration. Blood samples provided measures of cardiometabolic risk (CMR) factors.

Results: Almost one-third (32.8%) of young workers reported >38h working weeks. This was commonly reported in mining and construction industries for males; health and social assistance, mining, and retail trade industries for females. CMR factors including increased waist circumference, higher fasting plasma glucose, and reduced HDL-cholesterol, were associated with >38h working weeks. These relationships were not moderated by gender, or by BMI for glucose and HDL-cholesterol. Total sleep time was significantly lower in both male and female workers reporting >38h working weeks, but did not mediate the relationships seen with CMR factors.

Conclusions: These findings point to early associations between >38h working weeks and CMR risk, and highlight the potential benefit of making young employees aware of the health associations with working arrangements to reduce the longer-term relationships seen with working hours and poor cardiometabolic health in population studies.

Keywords: Working hours, sleep, cardiometabolic, Raine Study, health

1. Introduction

Awareness of the association between long working hours and physical health in the broader population is growing.(Cho et al. 2015) Despite negative associations between working hours, sleep loss and physical health in middle-aged and older workers, little is known about the influence of long working weeks on young workers' physical well-being. To date, research on poor health outcomes associated with employment in young workers has focused predominantly on factors influencing occupational health outcomes, including work-related illness and injury.(Hollenbeck, 2013) Such research has shown that young workers are more likely to be injured at work than their older counterparts (Safe Work Australia, 2010). Young workers are also over-represented in the casual workforce, making up 40% of this workforce in Australia (Blewett et al., 2014). Casual, or precarious, work has been associated with more negative work health and safety (WHS) outcomes, compared to full-time work (Park and Butler 2001). In addition, long working weeks combined with the unpredictable nature of casual work has been associated with significant disruption to the personal life and sense of work-life balance for young workers (Bohle, 2004). This may explain why young workers in Australia report high levels of absenteeism and presenteeism (at work but not functioning fully due to illness) (Straker et al., 2013; Kyaw-Myint et al., 2015). Taken together, it is evident that young workers may be at particularly high risk of negative health outcomes as a result of long working weeks. This is concerning as Australian Bureau of Statistics (ABS) quarterly labour force data (2014) indicate that Australian employees average a longer full-time working week (Workplace Gender Equality Agency, 2016) than the Australian Government recommendation of 38 hours per week (Fair Work Ombudsman, 2016). However, there are currently no empirical data in young workers that document the impact of long working weeks on cardiometabolic risk.

Given that both shorter sleep and increased cardiometabolic risks are reported in middle aged and older cohorts working long weeks (Kivimaki et al., 2017; Kivimaki et al., 2015; Virtanen et al., 2012), clarifying these relationships will be key to informing early intervention approaches to support young workers. Studies in middle-aged and older workers show diastolic blood pressure is increased in assembly-line employees who work more than 40h/week (Nakamura et al., 2012). Further, long working weeks are associated with an array of adverse cardiometabolic outcomes (Kobayashi et al. 2012; Kawakami et al., 1999) including atrial fibrillation (e.g. Kivimaki et al., 2017) and coronary heart disease (e.g. Virtanen et al. 2012). Of note, in middle-aged Australians the association between long working weeks and higher BMI is mediated by short sleep duration, suggesting that this may be one pathway linking long working weeks and obesity in middle-aged cohorts (Magee, Caputi & Iverson, 2011). In general, studies of associations between long working weeks and poor health outcomes have been undertaken in middle-aged and older workers (Escoto et al., 2010; Bannai and Tamakoshi 2013; Cho et al. 2015). It is unknown whether cardiometabolic risk indicators are affected by long working weeks in young workers, who are relatively new to the workforce and often have added time burdens associated with balancing study and work commitments which may influence this relationship. This paucity of data limits our understanding of the aetiology of working hours and increased cardiometabolic risk in the workforce. Clearer insight into the relationship between working hours and cardiometabolic health risks in young workers early in employment is an important addition to our current understanding of working hours and cardiometabolic health risk.

With this in mind, the primary aims of this research were to determine (1) the prevalence of working weeks longer than 38h in young Australian workers; (2) whether working weeks >38h were associated with increased cardiometabolic risk compared to ≤38h weeks; and (3) whether short sleep mediates the relationship between >38h working weeks and cardiometabolic risk.

2. Materials and Methods

2.1 Study population

Participants of this study were from the Western Australian Pregnancy Cohort (Raine) Study (also known as the Raine Study; **www.rainestudy.org.au)** (Straker et al., 2016). Briefly, the Raine Study is a longitudinal study of 2,868 live births from pregnancies recruited at 18 weeks gestation during the period 1989-1991 through the King Edward Memorial Hospital, Perth, Western Australia (Newnham et al., 1993). Data in this manuscript represent the first cross-sectional consideration of working hours relation to cardiometabolic risk factors for this cohort.

Active participants (*n*=2,086) were invited to participate in data collection around the date of their 22nd birthday. The Raine Study 22 year cohort follow-up was conducted with current ethics committee approval and informed written consent from all participants according to the Human Research Ethics Committee, University of Western Australia and Curtin University (ethics approval numbers: Curtin University (HR67/2013) and the University of Western Australia (RA/4/1/5202). The Raine cohort demographic characteristics are strongly representative of young adults in the Western Australian population (Straker et al., 2016).

2.2 Questionnaire

Raine participants completed a detailed participant questionnaire and in-clinic health assessment. This questionnaire included a question about current full- and part-time working arrangements which was used to filter participants from the analysis who were unemployed at the time of the survey. This questionnaire also asked about current industry of employment (Straker et al., 2015) (particularly as mining (Campbell, 2002) and construction (Lingard, Francis & Turner, 2010) are associated with long working weeks), hours of work per week, hours of total sleep during a typical weekday (including naps) and self-reported sleep quality over the last month (long working weeks are associated with less sleep and poorer sleep quality (Virtanen et al., 2009), insufficient sleep is associated with cardiometabolic risk factors (Knutson, 2010) and may represent one pathway by which health is affected). Participants were also asked whether they identified as a shiftworker (Y/N) as high proportions of shiftworkers report working days longer than eight hours (Kobayashi et al., 2012). Highest education level and total pay per week after tax (according to 2012 tax brackets) were collected as indicators of socioeconomic status.

2.3 Determining habitual working weeks (≤38h/week; >38h/week)

Typical working hours in a seven day week was assessed with two questions, to ensure the most accurate reflection of hours in a working week. Participants were asked to indicate how many hours per week they usually work in all (current) jobs, and how many hours their employer expected them to work in a typical seven day week. There was a strong correlation between these variables (r=0.91, p<0.001). Where participants had responded to both questions, an average value was calculated; where participants provided a response to only one working hours question this value was included. This approach was used to capture the potential working hours across a seven day period, and recognise that working hours may not be limited to those expected by a single paying employer. A total of 873 participants provided an estimate of working hours per week. The Australian Government recommends a working week of no more than 38 hours (Fair Work Ombudsman, 2016) as recent evidence in a large Australian cohort indicates that working more than 38 hours, particularly in women, has detrimental health consequences (Dinh, Strazdins & Welsh, 2017). These findings indicate a need to consider potential health impacts from a more conservative perspective in the modern workforce (>38 hours per seven day week) than existing literature which categorises longer working weeks from 40-48 hours. Accordingly, participants were divided into either ≤38h weeks (≤38 working hours per seven day week, and inclusive of casual and part-time workers) or >38h weeks (>38 working hours per seven day week) groups.

2.4 On-site physical assessment and blood samples

As reported previously trained research assistants collected information on height, weight, waist circumference and blood pressure (taken in a seated position using the Dinamap ProCare 100 Vital Signs Monitor from GE Healthcare Technologies, Rydalmere, Australia) (Straker et al., 2015; Le-Ha et al., 2013a; Le-Ha et al., 2013b). Blood samples were collected from a peripheral vein following an overnight fast (Straker et al., 2015), and assayed for glucose (collected in potassium oxalate/sodium fluoride tubes), triglycerides and high-density lipoprotein cholesterol (HDL-cholesterol; both analysed from serum) in the PathWest Laboratory at Royal Perth Hospital.

2.5 Determining cardiometabolic risk

Cardiometabolic risk has been quantified using calculation of a continuous clinical index of cardiometabolic (cCICR, e.g. Carroll et al., 2014; Okosun et al., 2010). Cardiometabolic risk factors were chosen for analysis based on previous variables used to calculate overall cardiometabolic and metabolic syndrome risk indices in adolescents (Okosun et al., 2010) and older adult populations (Carroll et al, 2014). These included waist circumference, mean arterial pressure (MAP; calculated as (2DBP+SBP)/3; note, MAP was used for cCICR in accordance with previous protocols, but systolic and diastolic blood pressure are reported as dependent variables) and fasting triglycerides, blood glucose and high density lipoprotein (HDL-cholesterol, to account for protective effects) were selected. Results are presented for individual cardiometabolic risk factors, as well as using a risk score for an overall continuous clinical index of cardiometabolic risk (cCICR), calculated based on the method of Carroll et al. (2014) and Okosun et al. (2010). The cCICR is composed of the five cardiometabolic risk factors selected. As each variable reflected close to a normal distribution, no transformations were conducted. Sex standardised z-scores using the sample means were calculated for each of the five risk factors, and the mean of these scores produced a cCICR risk score in accordance with previous methods (Carroll et al., 2014).

2.6 Data screening

Of the cohort who responded to the Year 22 questionnaire, 940 identified as current workers. This cohort was filtered for individuals who self-reported a previous diagnosis of obstructive sleep apnoea (OSA; n=9 overall, n=4 in the working sample). Participants were included for analysis if they provided a ‘no’ response to a diagnosis of OSA, and indicated that they were currently engaged in work. Fifty-five of the working respondents did not provide information on an OSA diagnosis (either yes or no), and were excluded from analyses. Of the 881 individuals who met the criteria for inclusion, 873 provided further details about expected hours of work in a seven day period, and were subsequently included in analyses.

2.7 Statistical analyses

Data were analysed with IBM SPSS Statistics (version 22.0, IBM Corporation). Continuous data were screened for normality. Continuous variables were parametrically distributed. Preliminary comparative descriptives were conducted to compare categorical (Pearson Chi square) and continuous (linear regression) risk factors (shift work, sleep duration and sleep quality) between participants reporting standard (≤38h/week) and long (>38h/week) working weeks. Mediated regression analyses were conducted to determine the relationship between both direct (working hours predicting cardiometabolic risk factors) and indirect (working hours predicting cardiometabolic risk factors mediated by total sleep time) using the PROCESS macro for SPSS (Hayes, 2013), with habitual smoking behaviour (y/n), work only versus combined work and study requirements, and shift work (y/n) as covariates. Bootstrapping analysis was performed to determine bias-corrected 95% confidence intervals (5000 bootstrap samples) (Preacher & Hayes, 2004). Finally, conditional process modelling was conducted to determine whether any moderation of mediated regression analyses was observed by sex. The *a priori* nature of the hypotheses, coupled with the highly conservative nature of Bonferroni adjustments and possible contribution to Type II errors meant Bonferroni corrections were not appropriate for these data (Nakagawa, 2004). However, given the potential for Type I errors with multiple comparisons with the related cardiometabolic risk factors in this dataset, a more conservative significance threshold of $p<0.01$ was applied to these data to quantify statistical significance.

3. Results

Almost one third (n=286, 32.8%) of all respondents indicated that their expected work hours exceeded 38 hours in a working week. Sample characteristics by standard versus long working weeks are provided in Table 1.

3.1 Work type and current industry

There was a strong association between reporting a long working week, and being male $\chi^2(1)=30.76$, $p<0.001$. While males represented 38.2% of the standard working week responses, over half of the long working week responses were from men. As a result, descriptives (Table 1) and industry frequencies (Table 2) are presented by gender. Mining was the most prevalent industry reported for males working a long working week, followed by construction. Health care and social assistance, mining, and retail trade were the most prevalent industries for long working weeks for women. A complete breakdown of industry by working week for males and females can be found in Table 2.

3.2. Shift work

Participants were asked to indicate whether they worked shift work. Of the male workers who reported a long working week, 26.7% reported being shift workers, compared with 32.1% of those working a standard working week ($\chi^2(1)=1.36$, $p=0.26$). Of the female workers who reported a long working week, 26.7% identified as a shift worker compared with 22.4% of workers who reported a standard working week ($\chi^2(1)=0.90$, $p=0.38$). Further descriptive breakdown by shift type are provided in Table 1; no significant differences were found between the shift groups.

3.3. Self reported sleep duration and quality

All participants were asked to provide an estimate of habitual weekday sleep time per night, and perceived sleep quality over the last month. Average weekday sleep was reduced in those reporting long working weeks by 21.7 mins for male workers (460.5(4.4) v 438.8(5.2); $F_{1,382}=10.14$, $p=0.002$) and by 22.7 mins for female workers (470.2(4.1) v 447.5(5.4); $F_{1,474}=8.87$, $p=0.003$). No association was found between long working weeks and self-reported sleep quality for males ($\chi^2(3)=6.4$, $p=0.09$) or females ($\chi^2(3)=4.50$, $p=0.21$), with the majority of respondents reporting 'fairly good' sleep quality over the last month (see Table 1).

3.5.Mediated regression analyses

Output from the mediated regression analyses is provided in Table 3. Sample sizes for each model were determined by available data for each cardiometabolic risk factor, as follows; waist circumference ($n=704$), glucose, triglycerides and HDL cholesterol ($n=653$), systolic and diastolic BP ($n=633$) and cCICR ($n=592$). All models were adjusted for highest education level, shift work status, time demands (work *v* work and study load), and smoking. The total effects model for waist circumference was significant ($R^2= 0.05$, $F_{5,698} = 6.66$, $p<0.001$), with a direct effect of working hours on waist circumference (see Table 3). Similarly, the full models for glucose ($R^2= 0.03$, $F_{5,647} = 3.89$,

p=0.002) and HDL cholesterol (R^2= 0.04, $F_{5,647}$ = 5.63, p<0.001) were significant, with long working weeks associated with increased glucose and decreased HDL cholesterol after controlling for covariates (see Table 3), and remained significant when controlling for BMI (see Supplementary Table 1). Full models for triglycerides (R^2= 0.01, $F_{5,647}$ = 1.60, p=0.158), diastolic BP (R^2= 0.01, $F_{5,627}$ = 1.84, p=0.104), systolic BP (R^2= 0.01, $F_{5,627}$ = 1.06, p=0.381) and calculated CICR (R^2= 0.02, $F_{5,586}$ = 1.90, p=0.092) were not significant. Long working weeks were associated with significantly shorter total sleep time in all models (all p<0.001, data not shown). However total sleep time did not mediate any of the observed relationships with cardiometabolic risk factors (all p>0.05; see Table 3).

The relationships between working hours and cardiometabolic risk factors, both directly and via mediation by total sleep time, may be moderated by sex. Post hoc conditional process modelling was conducted to determine whether sex moderated the direct and indirect effects in the models presented in Table 3. No moderating influence of sex was observed (all p>0.05; data not shown).

Table 1. Overall characteristics of the sample by type of working week

Measure	Standard week (≤38 hours)					Long week (>38 hours)				
	Mean	SE	N	(%)	Missing (n(%))	Mean	SE	N	(%)	Missing (n(%))
Gender	.	.	.	.	0(0)	.	.	.	.	0(0)
Female	.	.	363	61.8	.	.	.	120	42.0	.
Male	.	.	224	38.2	.	.	.	166	58.0	.
BMI (Kg/m^2)	24.73	0.22	.	.	77(13.1)	25.85	0.36	.	.	47(16.4)
Total Sleep Time (weekday; mins)	466.48	3.02	.	.	10(1.7)	442.47	3.77	.	.	3(1.0)
Sleep Quality over the last month	.	.	.	.	9(1.5)	.	.	.	.	2(0.7)
Very good	.	.	90	15.6		.	.	43	15.1	.
Fairly good	.	.	353	61.1		.	.	179	63.0	.
Fairly bad	.	.	125	21.6		.	.	55	19.4	.
Very bad	.	.	10	1.7		.	.	7	2.5	.
Shift Worker	.	.	.	.	2(0.3)	.	.	.	.	1(0.3)
Yes	.	.	153	26.2		.	.	76	26.6	.
No	.	.	432	73.8		.	.	209	73.1	.
Shift Type	.	.	.	.	46(7.8)	.	.	.	.	20(7.0)
Nil	.	.	432	73.6	.	.	.	212	74.1	.
Day shift only	.	.	29	4.9	.	.	.	14	4.9	.
Schedule with any nights	.	.	80	13.6	.	.	.	40	14.0	.
Expected work hours/7 days	22.74	0.46	.	.	0(0)	47.35	0.74	.	.	0(0)
Children (yes)	.	.	20	3.4	4(0.7)	.	.	10	3.5	3(1.0)
Living arrangements	.	.	.	.	1(0.2)	.	.	.	.	1(0.3)
With parents or step/parents	.	.	357	60.8	.	.	.	138	48.3	.
With a partner	.	.	59	10.1	.	.	.	54	18.9	.
With a partner and children	.	.	12	2.0	.	.	.	15	5.2	.
Share Accommodation	.	.	80	13.6	.	.	.	37	12.9	.
Alone	.	.	4	0.7	.	.	.	13	4.5	.
Other	.	.	74	12.6	.	.	.	30	10.5	.
Highest education level	.	.	.	.	3(0.5)	.	.	.	.	2(0.7)
Secondary (high) school	.	.	287	48.9	.	.	.	127	44.4	.

TAFE/college	.	.	111	189	.	.	.	86	30.1	.
University	.	.	177	30.2	.	.	.	59	20.6	.
Other (e.g personal training course)	.	.	9	1.5	.	.	.	12	4.2	.
Weekly income range	.	.	.	.	6(1.0)	.	.			2(0.7)
<$116 per week	.	.	42	7.2	.	.	.	0	0.0	
$116-$604 per week	.	.	353	60.1	.	.	.	29	10.1	
$605-$1076 per week	.	.	162	27.6	.	.	.	168	58.7	
$1077-$2180 per week	.	.	24	4.1	.	.	.	68	23.8	
>$2180 per week	.	.	0	0.0	.	.	.	19	6.6	
Current work / study arrangements	.	.	.	.	25(4.3)	.	.	.	.	5(1.7)
Work only (including paid apprenticeships)	.	.	387	65.9		.	.	246	86.0	
Work and study commitments	.	.	175	29.8		.	.	35	12.2	

Note: SE, standard error of the mean; N, number of respondents; BMI, body mass index; h, hours; ., =category not applicable

Table 2. Number of respondents per industry by standard (≤38h/week) and long (>38h/week) working weeks

Industry	MALE				FEMALE			
	Standard Week		Long Week		Standard Week		Long Week	
	n	%	n	%	n	%	n	%
Agriculture, Forestry and Fishing	0	0.0	0	0.0	2	0.6	2	1.7
Mining	5	2.2	30	18.2*	3	0.8	16	13.3*
Manufacturing	6	2.7	13	7.9	1	0.3	4	3.3
Electricity, Gas, Water and Waste Services	3	1.3	5	3.0	4	1.1	0	0.0
Construction	15	6.7	35	21.2*	5	1.4	5	4.2
Wholesale Trade	1	0.4	2	1.2	2	0.6	3	2.5
Retail Trade	64	28.7^	12	7.3	88	24.4^	16	13.3*
Accommodation and Food Services	37	16.6^	11	6.7	68	18.9^	7	5.8
Transport, Postal and Warehousing	12	5.4	8	4.8	2	0.6	4	3.3
Information Media and Telecommunications	4	1.8	5	3.0	3	0.8	4	3.3
Financial and Insurance Services	3	1.3	3	1.8	7	1.9	7	5.8
Rental, Hiring and Real Estate Services	0	0.0	0	0.0	2	0.6	1	0.8
Professional, Scientific and Technical Services	8	3.6	8	4.8	14	3.9	2	1.7
Administrative and Support Services	1	0.4	2	1.2	9	2.5	5	5.0
Public Administration and Safety	2	0.3	11	6.7	12	3.3	4	3.3
Education and Training	12	5.4	2	1.2	35	9.7	9	7.5
Health Care and Social Assistance	19	8.5	4	2.4	62	17.2	19	15.8*
Arts and Recreation Services	18	8.1	2	1.2	18	5.0	5	4.2
Other Services	13	5.8	12	7.3	23	6.4	7	5.8

Note: ^denotes 2 most common industries for workers who reported a standard working week, *denotes 2 most common industries for workers who reported a long working week

Table 3. Mediated regression analyses showing the relative total effects on cardiometabolic risk factors of working hours, and the relative indirect effect of working hours on cardiometabolic risk factors through total sleep time

CMR Factor	**Factor**	**Mean(±SEM)**	***B***	***SE***	***p***	**95% CI**
Waist Circumference (*cm*)	Working hours		3.37	1.07	**0.002**	**1.27, 5.47**
	≤38h/week	81.54(±0.55)				
	>38h/week	85.49(±0.96)				
Relative indirect effect of working hours through TST			0.15	0.20	.	-0.22, 0.56
Glucose (*mmol/L*)	Working hours		0.12	0.04	**0.001**	**0.05, 0.19**
	≤38h/week	4.93(±0.02)				
	>38h/week	5.05(±0.03)				
Relative indirect effect of working hours through TST			0.01	0.01	.	-0.00, 0.02
Triglycerides (*mmol/L*)	Working hours		0.02	0.04	0.621	-0.06, 0.10
	≤38h/week	1.08(±0.02)				
	>38h/week	1.11(±0.04)				
Relative indirect effect of working hours through TST			-0.00	0.01	.	-0.02, 0.01
HDL-Cholesterol (*mmol/L*)	Working hours		-0.10	0.03	**<0.001**	**-0.15, -0.05**
	≤38h/week	1.41(±0.02)				
	>38h/week	1.30(±0.02)				
Relative indirect effect of working hours through TST			-0.00	0.01	.	-0.01, 0.01
Diastolic (*mmHg*)	Working hours		-0.04	0.65	0.949	-1.33, 1.24
	≤38h/week	64.23(±0.35)				
	>38h/week	64.14(±0.50)				
Relative indirect effect of working hours through TST			0.03	0.10	.	-0.17, 0.24
Systolic (*mmHg*)	Working hours		1.21	0.97	0.215	-0.70, 3.12
	≤38h/week	116.79(±0.52)				
	>38h/week	118.34(±0.71)				
Relative indirect effect of working hours through TST			0.09	0.16	.	-0.20, 0.45
cCICR	Working hours		0.11	0.05	0.026	0.01, 0.21
	≤38h/week	-0.03(±0.03)				
	>38h/week	0.09(±0.04)				
Relative indirect effect of working hours through TST			-0.00	0.01	.	-0.02, 0.02

Note: all models adjusted for smoking, time demands (work only versus work and study) socioeconomic status and shift work (socioeconomic status represented as highest educational level attained); boldface indicates significant direct relationships between working hours and cardiometabolic risk factors; CMR, cardiometabolic risk; SEM, standard error of the mean; cm, centimeters; mmol/L, millimol per litre; mmHg, millimetre of mercury; cCICR, clinical index of cardiometabolic risk; TST, total sleep time; CI, confidence interval

4. Discussion

This study is the first to consider differences in cardiometabolic risk factors in young workers in Australia according to whether they worked >38h working weeks. Industries with the highest frequency of participants with long working weeks included mining for both male and female participants, construction for males, and health care and social assistance for females. Waist circumference and fasting blood glucose levels were increased, and HDL cholesterol levels decreased, in young workers who indicated > 38h weeks, when controlling for shift work status, time demands (work only *v* work and study demands), smoking, and socioeconomic status. The relationship between >38h working weeks, glucose and HDL-cholesterol appeared to be independent of effects on adiposity as the association remained significant after adjusting for BMI. Cardiometabolic changes may emerge early in working life with a higher burden of occupational time during the week, irrespective of shift work status and part time study load. While >38h working weeks were associated with less total sleep time, total sleep time did not mediate the associations found with cardiometabolic risk factors. Further, associations between >38h working weeks and cardiometabolic factors did not differ by sex. Together, these findings suggest that even with a modest cut-off of >38h working weeks, there is an association with differences in certain cardiometabolic risk factors in young workers, and the pathway is not mediated by total sleep time.

The finding that mining and construction are industries associated with >38h working weeks is consistent with existing data (Lingard, 2010; Campbell, 2002). Working weeks >38h in the health care and social assistance industry for female participants in this cohort are reflective of existing Australian and New Zealand research in nurses, with over 40% of the sample (>90% female) reporting long working weeks (>40h/week). The working weeks >38h per week in mining and construction reported by male participants may be a consequence of fly-in/fly-out (FIFO) and/or drive-in/drive-out (DIDO) employment, which is prevalent in Western Australia (WA) where this cohort is based (Henry et al., 2013). While exact numbers of FIFO/DIDO employment in WA are difficult to discern based on existing literature (Education and Health Standing Committee, 2015), it is thought that close to 60% of operational mining employees are employed on a FIFO/DIDO schedule, while approximately 80% of construction mining employees are FIFO/DIDO. FIFO and DIDO roles in Western Australia are typically filled by the younger (18-44year), male workforce. Thus, it is plausible that >38h working weeks in this cohort may also be a function of FIFO/DIDO practices, which can demand more complex commuting arrangements to access airports and work sites (McKenzie, 2016), potentially affecting duration of working weeks, and impacting on sleep duration. While FIFO/DIDO requirements could not be determined from these data, it would be worthwhile in future to identify these workers in the cohort as FIFO/DIDO practices could contribute to poorer health in young workers.

The finding that some cardiometabolic risk factors are associated with >38h working weeks supports the poor health outcomes reported in the literature for middle-aged and older cohorts, and suggests that negative health changes likely begin early in careers for young workers with >38h working weeks even when controlling for potential confounders such as employment as a shift worker, time demands, smoking and socioeconomic status. Coronary heart disease (Kivimäki et al. 2015; Virtanen et al., 2012), stroke (Kivimäki et al. 2015), obesity (Solovieva, Lallukka & Virtanen, 2013), type 2 diabetes (Kawakami et al., 1999), and metabolic syndrome (Kobayashi et al., 2012) are all associated with long working weeks, but these studies to date have predominantly been reported in middle-aged and older cohorts. This has limited understanding of the early patterns of health changes in younger workers, and impacts our capacity to identify those at greater risk of negative cardiometabolic outcomes in the medium to long term. Our findings highlight that even a conservative benchmark of >38h worked per week is sufficient to identify health factors which would benefit from early monitoring, including central adiposity (waist circumference), measurement of blood glucose and HDL cholesterol levels. Together, these routine measures may facilitate early identification and intervention of workers at risk of negative health outcomes associated with >38h working weeks.

In context of our findings, it is likely that the relationship between working hours and negative cardiometabolic outcomes seen in older cohorts is a consequence of chronic exposure to >38h working weeks, with a cumulative impact on cardiometabolic health over time. Our discovery of early differences in cardiometabolic risk factors in those working >38h weeks suggests a need for early intervention if we are to improve the long-term health of those exposed to longer working hours, particularly in occupations where such work schedules may not be as easily adjusted to a recommended working hour arrangement. The absence of a mediating influence of total sleep time despite a relationship between >38h working weeks and reduced sleep may indicate that unhealthy lifestyles (including diet, sedentary behaviour and exercise changes) account for some of the unexplained variance in the models presented. Future studies should consider changes in food intake and exercise opportunities in workers to better understand the mediating factors linking working hours with cardiometabolic risk factors. Additional consideration of industry-related factors should also be a factor in larger cohorts, as there may be industry-specific exposures which account for variance in working hours and cardiometabolic risk.

While the average total sleep time in each working category represents what is considered a 'healthy' sleep opportunity for adults (Watson et al., 2015), the self-reported sleep durations in this cohort represent the lower end of the National Sleep Foundation's recommendation of 7-9 hours per night for 18-25 year olds (Hirshkowitz et al., 2015). Further, a sizable proportion of the sample overall reported fewer than the recommended 7h per night. Chronic, partial sleep loss of this kind is associated with negative neurobehavioural (Van Dongen et al., 2003) and glucose response (Reynolds et al., 2012) outcomes. The impact of shorter sleep duration on cardiometabolic risk factors is further supported by prospective studies which show greater weight gain (overall gain, and proportion of subcutaneous and visceral fat increase) over time (up to five years) in those who report shorter sleep durations (Patel & Hu, 2008). As the present study reflects a cross-sectional investigation of the relationship between working hours and cardiometabolic risk, the significantly shorter sleep duration found in the >38h working week sample will need to be followed longitudinally to determine whether ongoing shorter sleep is associated with cardiometabolic risk factors over time in young Australian workers. It is possible that the shorter sleep duration in these workers precedes the cardiometabolic risk factors seen in older workers with long weeks. Considering nap time and night sleep separately, inclusion of more objective measurement of sleep duration, and use of similar recall periods for sleep variables in future will enable a clearer picture of any nocturnal sleep loss in this cohort.

Our findings should be considered in light of some methodological limitations. While we were able to adjust for smoking, socioeconomic status, shift work status and time demands as covariates, additional behavioural factors could be considered in this relationship in future, including alcohol consumption, food intake and physical activity/ sedentariness given the association between these factors and cardiometabolic health risks. Our measures of total sleep time and working hours were derived from self-report measures with different recall periods, which may have influenced the findings. Where possible, an average response on working hours from two slightly differently framed questions was reported for the working hours variable, however more objective indicators of habitual working weeks would be beneficial in future. Similarly, including a subset of objective sleep measurement (e.g. actigraphy) in the cohort for future followup would provide an indicator of accuracy of self-reported sleep time. Consideration of job roles and impact of work type, work/life balance and the potential role these factors may play in the relationship between working hours and cardiometabolic health risk in future studies would further strengthen our understanding, particularly as younger workers may have additional time demands including young families, and concurrent work and study schedules, to consider.

The aim of this study was to determine any industry, work type and cardiometabolic risk factor differences between young workers engaged in standard versus long working weeks, and determine whether sleep duration mediated any associations with long working weeks. To this end, this study has not considered the psychosocial and occupational demands associated with particular employment conditions, or other psychological and physiological outcomes which may be impacted by long working hours in young workers. This can be addressed in future cohort follow-ups with inclusion of job stress and demand measures, and consideration of additional health outcome measures. Further, it was not possible to determine the proportion of long working week respondents who were engaged in FIFO/DIDO employment. Including additional indices of employment type will be beneficial to elucidate the impact of FIFO/DIDO employment in this cohort in future. Our cut-point of 38h per week was determined by Australian Government recommendations for working weeks to illustrate potential consequences of exceeding these recommendations. Even with this conservative benchmark of long working weeks we identified cardiometabolic risk factors associated with longer working weeks. This study reports outcomes from the first timepoint in this cohort exploring working hours and objective indicators health, however the longitudinal nature of this cohort will allow for future consideration of occupational hours exposure over time. Mapping the longitudinal profile of cardiometabolic risk factors in young Australian workers with future Raine cohort follow ups will allow for a novel evaluation of the health risk changes associated with working hours beyond the recommended 38h per week in Australia, and consideration of any long-term impacts of sleep restriction on health in those engaged in long working weeks.

5. Conclusions

These findings provide novel insights into the relationship between working weeks, cardiometabolic risk factors and sleep duration in young Australian workers. Increased waist circumference and fasting blood glucose levels together with decreased HDL cholesterol levels, were apparent in young workers who reported >38h working weeks. These data suggest young workers may be vulnerable to poor cardiometabolic health outcomes with >38h working weeks, and provide new evidence that working hours may contribute to increased cardiometabolic risk early in working life. Findings of longer average working weeks in mining, construction, and health and social assistance industries provide a starting point for targeted educational opportunities to inform both employers and young workers about the potential health consequences of longer working weeks and short sleep, and highlight the need for early awareness of the relationship between longer working hours and health outcomes in young Australian adults.

Funding

The 22 year Raine Study follow-up was funded by National Health and Medical Research Council of Australia project grants (1027449 (Eastwood et al), 1044840 (Straker et al) and 1021855 (Hall et al)), Future Health WA (G06302, Eastwood et al) and Safe Work Australia.

Conflicts of Interest

CQUniversity Australia (ACR, JLP and SAF) have a collaborative research agreement with microbial genomics company uBiome. No financial interests are held, but the project is expected to generate research publications. PRE, LMS and TAM are funded by NHMRC Senior Research Fellowships (Nos. 1042341, 1019980 and 1042255, respectively). SAF's research is currently supported by Australian Research Council (ARC) grant DP150104497, and ACR, JLP and SAF have previously been funded by SafeWork SA. RSB has grants from the NHMRC and ARC unrelated to this work and receives royalties from Hogrefe Publishers for the publication of memory test. The authors declare they have no conflict of interest.

9. References

Bannai A, Tamakoshi A. (2013) The association between long working hours and health: A systematic review of epidemiological evidence. *Scand J Work Environ Health*;**40**:5–18.

Blewett V, Rainbird S, Clarkson L, Etherton, H, Paterson, J. (2014) Strategic engagement: Hearing the voice of young workers in the development of the youth work health and safety strategy for South Australia. In: Mitchell R, ed. *Then, now and beyond proceedings of the 40th Annual Conference of the Human Factors and Ergonomics Society of Australia Inc., - November, Adelaide, Australia, Human Factors and Ergonomics Society of Australia*. Baulkham Hills, NSW, Aus.

Bohle P, Quinlan M, Kennedy D, Williamson, A. (2004) Working hours, work-life conflict and health in precarious and "permanent" employment. *Rev Saúde Pública*;**38**:19–25.

Campbell I. (2002) Extended working hours in Australia. *Labour and Industry*;**13**:91–110.

Carroll SJ, Paquet C, Howard NJ, *et al.* (2014) Validation of continuous clinical indices of cardiometabolic risk in a cohort of Australian adults. *BMC Cardiovascular Disorders*;**14**:743.

Cho S-S, Ki M, Kim K-H, Ju, Y-S, Paek, D *et al.* (2015) Working hours and self-rated health over 7 years: gender differences in a Korean longitudinal study. *BMC Pub Health*;**15**:515.

Dinh, H, Strazdins, L, Welsh, J. (2017) Hour-glass ceilings: Work-hour thresholds, gendered health inequities. *Social Science & Medicine*;**176**:42-51.

Education and Health Standing Committee. (2015) The impact of FIFO work practices on mental health: Final Report.. Parliament of Western Australia, Perth WA.

Escoto KH, French SA, Harnack LJ, *et al.* (2010) Work hours, weight status, and weight-related behaviors: a study of metro transit workers. *Int J Behav Nutr Phys Act*;**7**:91.

Fair Work Ombudsman. (2016) Hours of work. https://www.fairwork.gov.au/employee-entitlements/hours-of-work-breaks-and-rosters/hours-of-work (accessed 10 May 2016)

Hayes, A.F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach:* Guilford Press.

Henry P, Hamilton K, Watson S, *et al.* (2013) FIFO/DIDO mental health research report 2013. Lifeline, WA http://www.lifelinewa.org.au/download/FIFO+DIDO+Mental+Health+Research+Report+2013.pdf

Hirshkowitz M, Whiton K, Albert SM, *et al.* (2015) National Sleep Foundation's sleep time duration recommendations: Methodology and results summary. *Sleep Health*;**1**:40–3.

Hollenbeck J. (2013) Beyond occupational safety: Health and well-being promotion for young workers. *141st APHA Annual Meeting and Exposition*; 3304.1.

Kawakami N, Araki S, Takatsuka N, *et al.* (1999) Overtime, psychosocial working conditions, and occurrence of non- insulin dependent diabetes mellitus in Japanese men. *J Epidemiol Community Health*;**53**:359–63.

Kivimäki M, Nyberg ST, Batty, G.D. *et al.* (2015) Long working hours as a risk factor for atrial fibrillation: A multi-cohort study *Eur Heart Journal*;**38**:2621–28.

Kivimäki M, Jokela M, Nyberg ST, *et al.* (2015) 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. *The Lancet*;**386**:1739–46.

Knutson KL. Sleep duration and cardiometabolic risk: A review of the epidemiologic evidence. *Best Pract Res Clin Endocrinol Metab* 2010;**24**:731–43.

Kobayashi T, Suzuki E, Takao S, *et al.* (2012) Long working hours and metabolic syndrome among Japanese men: A cross-sectional study. *BMC Pub Health*; **12:**395.

Kyaw-Myint S, Smith SA, Beales D, Job, J, Straker, L. (2015) Work productivity loss among young workers. Canberra: Safe Work Australia.

Le-Ha C, Beilin LJ, Burrows S, *et al.* (2013a) Oral contraceptive use in girls and alcohol consumption in boys are associated with increased blood pressure in late adolescence. *Eur J Prev Cardiol*;**20**:947–55.

Le-Ha C, Beilin LJ, Burrows S, *et al.* (2013b) Gender difference in the relationship between passive smoking exposure and HDL-cholesterol levels in late adolescence. *J Clin Endocrinol Metab*;**98**:2126–35.

Lingard HC, Francis V, Turner M. (2010) Work–family enrichment in the Australian construction industry: Implications for job design. *Construction Management and Economics*;**28**:467–80.

Magee CA, Caputi P, Iverson DC. (2011) Short sleep mediates the association between long work hours and increased body mass index. *J Behav Med*;**34**:83–91.

McKenzie F. (2016) Long distance commuting and regional development: A case study of Stawell, Victoria. Melbourne, VIC: Spatial Analysis and Research, Department of Transport, Planning and Local Infrastructure http://www.dtpli.vic.gov.au/__data/assets/pdf_file/0009/222939/Stawell-Report.pdf (accessed 10 May 2016)

Nakagawa S. (2004) A farewell to Bonferroni: The problems of low statistical power and publication bias. *Behav Ecol*;**15**:1044–5.

Nakamura K, Sakurai M, Morikawa Y, Miura, K, Ishizaki, M *et al.* (2012) Overtime work and blood pressure in normotensive Japanese male workers. *Am J Hypertens*;**25**:979–85.

Newnham JP, Evans SF, Michael CA, *et al.* Effects of frequent ultrasound during pregnancy: A randomized controlled trial. *The Lancet* 1993;**342**:887–91.

Okosun IS, Lyn R, Davis-Smith M, *et al.* (2010) .Validity of a continuous metabolic risk score as an index for modeling metabolic syndrome in adolescents. *Annals Epidemiol*;**20**:843–51.

Park Y-S, Butler RJ. (2001) The safety costs of contingent work: Evidence from Minnesota. *J Labor Res* ;**22**:831–49.

Patel SR, Hu FB. (2004) Short sleep duration and weight gain: A systematic review. *Obesity* 2008;**16**:643–53

Preacher, K.J., & Hayes, A.F. (2004). SPSS and SAS procedure for estimating indirect effects in simple mediation models. *Behavior Research Methods, Instruments, & Computers, 36*(4), 717-731.

Reynolds AC, Dorrian J, Liu PY, *et al.* (2012) Impact of five nights of sleep restriction on glucose metabolism, leptin and testosterone in young adult men. *PloS one*;**7**:e41218.

Safe Work Australia. (2010) Work-related injuries experienced by young workers in Australia, 2009-10. http://www.safeworkaustralia.gov.au/sites/SWA/about/Publications/Documents/764/work-related-injuries-experienced-young-workers-Australia-2009-10.pdf

Solovieva S, Lallukka T, Virtanen M. (2013) Psychosocial factors at work, long work hours, and obesity: A systematic review. *Scand J Work Environ Health*;**39**:241-58.

Straker L, Beales D, Job J, Kyaw-Myint, S, Smith, A, *et al.* (2013) Young workers at risk: Absenteeism and presenteeism in Raine study 23 year olds. *Human Factors and Ergonomics Society of Australia Inc. (HFESA).*

Straker LM, Hall GL, Mountain J, *et al.* (2015) Rationale, design and methods for the 22 year follow-up of the Western Australian Pregnancy Cohort (Raine) Study. *BMC Pub Health*;**15**:887.

Straker L, Mountain J, Jacques A, *et al*. (2017) Cohort profile: The Western Australian pregnancy cohort (Raine) study – Generation 2. *Int J Epidemiol.* http://doi.org/10.1093/ije/dyw308

Van Dongen HPA, Maislin G, Mullington JM, *et al.* (2003) The cumulative cost of additional wakefulness: Dose-response effects on neurobehavioral functions and sleep physiology from chronic sleep restriction and total sleep deprivation. *Sleep*;**26**:117–26.

Virtanen M, Hekkilä, K, Jokela, M, *et al.* (2012) Long working hours and coronary heart disease: A systematic review and meta-analysis. *Am J Epidemiol*;**176**:586-96.

Virtanen M, Ferrie J, Gimeno D, *et al.* (2009) Long working hours and sleep disturbances: The Whitehall II prospective cohort study. *Sleep*;**32**:737–45.

Virtanen M, Ferrie JE, Singh-Manoux A, Shipley, MJ, Vahtera, J, *et al.* (2010) Overtime work and incident coronary heart disease: The Whitehall II prospective cohort study. *Eur Heart J*;**31**:1737–44.

Watson NF, Badr MS, Belenky G, *et al.* (2015) Recommended amount of sleep for a healthy adult. *J Clin Sleep Med*;**11**. doi:10.5664/jcsm.4758

Workplace Gender Equality Agency. Gender composition of the workforce: By industry. (2016) httpswww.wgea.gov.ausitesdefaultfiles---Gendercomposition-of-the-workforce-by-industry.pdf. https://www.wgea.gov.au/sites/default/files/2014-04-04-Gender%20composition-of-the-workforce-by-industry.pdf (accessed 10 May 2016).

Supplementary Table 1. Mediated regression analyses with inclusion of BMI as a covariate showing the relationship between working hours and cardiometabolic risk factors directly, and the significance of mediation by total sleep time

CMR Factor	**Factor**	***B***	***SE***	***p***	**95% CI**	**Model**		
						R^2	***F***	***df***
Glucose (*mmol/L*)	Working hours *≤38h/week* *>38h/week*	0.11	0.04	**0.003**	**0.04, 0.18**	0.05	6.15	6,645
Relative indirect effect of working hours through TST		0.01	0.01	.	-0.00, 0.02			
HDL-Cholesterol (*mmol/L*)	Working hours *≤38h/week* *>38h/week*	-0.10	0.03	**0.004**	**-0.13, -0.02**	0.12	15.16	6,645
Relative indirect effect of working hours through TST		-0.00	0.00	.	-0.01, 0.01			

Note: total effects models adjusted for smoking, time demands (work only versus work and study), socioeconomic status and shift work (socioeconomic status represented as highest educational level attained) and BMI; boldface indicates significant direct relationships between working hours and cardiometabolic risk factors; cm, centimeters; mmol/L, millimol per litre; BMI, body mass index (log10 transformed); TST, total sleep time; CI, confidence interval