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Influence of the workplace on physical activity and cardiometabolic health: Results of the multi-centre cross-sectional Champlain Nurses' study

Jennifer L. Reed[a,b,*], Stephanie A. Prince[a], Andrew L. Pipe[a], Suzanne Attallah[a], Kristi B. Adamo[b], Heather E. Tulloch[a], Douglas Manuel[c], Kerri-Anne Mullen[a], George Fodor[a], Robert D. Reid[a]

[a] Division of Cardiac Prevention and Rehabilitation, University of Ottawa Heart Institute, Canada
[b] School of Human Kinetics, Faculty of Health Sciences, University of Ottawa, Canada
[c] Ottawa Hospital Research Institute, Canada

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ABSTRACT

Background: Nurses are the largest professional group within the health care workforce, and their work is perceived as being physically demanding. Regular physical activity helps to prevent or ameliorate cardiometabolic conditions (e.g. cardiovascular disease, diabetes). It is not known whether Canadian nurses are meeting current physical activity guidelines.
Objective: To assess the influence of the workplace on the physical activity and cardiometabolic health of nurses from hospitals in the Champlain region of Ontario, Canada.
Design: A multi-centre, cross-sectional study.
Setting: Hospitals in the Champlain Local Health Integration Network of Ontario.
Methods: Nurses wore an ActiGraph accelerometer to objectively assess levels of moderate-to-vigorous intensity physical activity measured in minutes/day in bouts ≥ 10 min. All completed the Perceived Workplace Environment (PWE) scale and International Physical Activity Questionnaire (IPAQ). Height, body mass, waist circumference, blood pressure and heart rate were measured, and body mass index (BMI) was determined. Each nurse's 5-year cardiovascular risk was calculated using the Harvard Score.
Findings: A total of 410 nurses (94% female; mean $\pm$ SD: age = 43 $\pm$ 12 years) from 14 hospitals participated. Nurses spent an average of 96 $\pm$ 100 min/week in bouts ≥ 10 min of moderate-to-vigorous intensity physical activity; 23% of nurses met recommended physical activity guidelines. Nurses working 8- vs. 12-h shifts (16 $\pm$ 16 vs. 10 $\pm$ 11 min/day, $p = 0.026$), fixed vs. rotating shifts (15 $\pm$ 15 vs. 12 $\pm$ 13 min/day, $p = 0.012$) and casual vs. full-time (29 $\pm$ 17 vs. 13 $\pm$ 15 min/day, $p < 0.001$) or vs. part-time (29 $\pm$ 17 vs. 13 $\pm$ 12 min/day, $p = 0.001$) accumulated more moderate-to-vigorous intensity physical activity in bouts ≥ 10 min. The average PWE score was 2.4 $\pm$ 0.9, with no association between PWE scores and moderate-to-vigorous intensity physical activity in bouts ≥ 10 min ($p > 0.05$). Nurses working 8-h shifts, fixed shifts and in urban hospitals reported better PWE scores ($p < 0.05$). Nurses working fixed vs. rotating shifts had higher systolic blood pressure (median: 114 vs. 112 mmHg, $p = 0.043$), and nurses working in rural vs. urban hospitals had higher BMI (median: 27.8 vs. 25.6 kg/m^2, $p = 0.007$) and waist circumference (median: 82.3 vs. 78.6 cm, $p = 0.015$).
Conclusions: Nurses are not meeting current physical activity guidelines (150 min of moderate-to-vigorous intensity physical activity per week in 10-min bouts), yet exceeded these recommendations when examining their continuous (i.e. non bouts) physical activity levels. No association between the PWE and moderate-to-vigorous intensity physical activity was observed. Rotating vs. fixed shifts, 12- vs. 8-h shifts, and/or full-time or part-time vs. casual hours may impede nurses' ability to meet recommended physical activity levels. The low physical activity levels and poor cardiometabolic health of Canadian nurses warrant attention.

* Corresponding author at: Division of Cardiac Prevention and Rehabilitation, University of Ottawa Heart Institute, 40 Ruskin Street, Ottawa, Ontario, K1Y 4W7, Canada.
E-mail addresses: jreed@ottawaheart.ca (J.L. Reed), sprinceware@ottawaheart.ca (S.A. Prince), apipe@ottawaheart.ca (A.L. Pipe), suzanne.attallah@gmail.com (S. Attallah), kadamo@uottawa.ca (K.B. Adamo), HETulloch@ottawaheart.ca (H.E. Tulloch), dmanuel@ohri.ca (D. Manuel), KMullen@ottawaheart.ca (K.-A. Mullen), george.fodor@gmail.com (G. Fodor), breid@ottawaheart.ca (R.D. Reid).

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What is already known about the topic?

- Nurses are the largest professional group within the health care workforce.
- The poor self-reported health of Canadian nurses appears to contribute to high rates of absenteeism.
- Irrefutable evidence demonstrates the effectiveness of regular physical activity in the prevention and management of chronic conditions (e.g. cardiovascular disease, hypertension, high cholesterol, diabetes, osteoarthritis, osteoporosis, depression, certain cancers).

What this paper adds

- Few nurses met the current Canadian physical activity guidelines (150 min of moderate-to-vigorous intensity physical activity per week in 10-min bouts), yet nurses exceeded these recommendations when examining their continuous (i.e. non bouts) physical activity levels.
- Nurses working 8-h shifts, fixed shifts or casually accumulated greater physical activity levels.
- Nurses working 8-h shifts, fixed shifts, in outpatient, mental health, imaging, administration and research, and in urban hospitals reported better perceived workplace environment.
- A substantial number of nurses presented with and/or reported several cardiovascular risk factors (i.e. obese/overweight, poor mental health, smoking, hypertension, high cholesterol, and diabetes).
- Most nurses had a low risk of having a fatal or non-fatal cardiovascular event in the next five years.

1. Introduction

Nurses represent the largest professional group within the health care workforce (Canadian Federation of Nurses Unions, 2013). Findings from the *National Survey of the Work and Health of Nurses in Canada* revealed that an alarming proportion of Canadian nurses report: being overweight or obese (45%), having high blood pressure (13%), smoking (11%), having high cholesterol (10%), experiencing depression (9%) or being diabetic (3%) (Shields and Wilkins, 2006) – all known modifiable risk factors for cardiovascular disease (Khawaja et al., 2009; Public Health Agency of Canada, 2009). Such poor health appears to contribute to high rates of absenteeism; more than 24,000 nurses (9%) were absent each week in 2016 as a result of personal illness or injury (Jacobson Consulting Inc, 2017). This level of absenteeism is substantially higher than the national average for all other occupations (6%) (Jacobson Consulting Inc, 2017). The annual cost of such absenteeism continues to increase and was estimated at $989 million in 2016 (Jacobson Consulting Inc, 2017).

Irrefutable evidence demonstrates the effectiveness of regular physical activity in the prevention and management of chronic conditions (e.g. cardiovascular disease, hypertension, high cholesterol, diabetes, osteoarthritis, osteoporosis, depression, certain cancers) (Baillot et al., 2015; Haskell et al., 2007; Reed and Pipe, 2016; Warburton et al., 2010, 2006). The Canadian Society for Exercise Physiology and World Health Organization recommend that adults accumulate at least 150 min of moderate-to-vigorous intensity physical activity per week in bouts of at least 10 min (Canadian Society for Exercise Physiology, 2011; World Health Organization, 2011). The disquieting proportion of Canadian nurses reporting poor health suggests that their health behaviours, including physical activity, may be suboptimal. Several investigators in varied settings have assessed the self-reported and objective physical activity levels of nurses (e.g. Australia, Canada, Iceland, Thailand, United States) and shown low levels of physical activity (Babiolakis et al., 2015; James et al., 2013; Kaewthummanukul et al., 2006; Perry et al., 2015; Ratner and Sawatzky, 2009; Sveinsdottir and Gunnarsdottir, 2008). None have objectively measured physical activity levels using activity monitors and examined the influence of the hospital environments in which nurses spend a substantial proportion of their waking hours. Workplaces have been shown to play an important role in employees' physical activity levels and cardiometabolic health (Morris et al., 1953; Reed et al., 2017; Tigbe et al., 2017; van der Ploeg et al., 2015). Nurses' often engage in rotating shifts, which have been associated with an increased risk of coronary heart disease (Vetter et al., 2016).

The purpose of this multi-centre, cross-sectional study was to assess the influence of the workplace (i.e. hours, shifts, work status, hospital and area location, perceived workplace physical activity environment) on physical activity levels and the cardiometabolic health of Canadian nurses from a blend of rural and urban hospitals in the Champlain region of Ontario, Canada. A secondary purpose was to examine the associations across physical activity levels, steps per day, Perceived Workplace Environment (PWE) scores and cardiometabolic health indicators. We hypothesized that the majority of nurses would present with low levels of physical activity and poor cardiometabolic health, and these, in turn, would be associated with the characteristics and perceptions of the workplace.

2. Methods

2.1. Study design

This was a multi-centre, cross-sectional study led by the University of Ottawa Heart Institute (UOHI). The study received ethics approval from 11 hospital research ethics boards (Protocol #: 20140670-01H; Protocol #: 15/22X; Protocol #: JR-21-01-15; Protocol #: 2015008; Protocol #: 15-04; Protocol #: 2014-003; Protocol #: 20140670-01H; Protocol #: none; Protocol #: 2014-1011; Protocol #: 20140670-01H; Protocol #: none). All participants provided written, informed consent prior to participation.

2.2. Recruitment of workplaces and participants

We approached 20 hospitals (a blend of rural and urban) from the Champlain Local Health Integration Network of Ontario extending an invitation to participate in this study; 14 hospitals agreed. All participants were recruited between December 2014 and January 2016. Research staff travelled to each hospital to inform nurses and nursing leaders of the study by attending nursing meetings and conferences and, distributing recruitment posters throughout the hospital (e.g. nursing lounges and stations, information boards, cafeterias). The posters contained a brief description of the study, contact information and links to the Champlain Nurses' Study social media accounts (i.e. Facebook, Twitter). Research personnel also staffed recruitment booths and provided information sessions at hospitals during National Nursing Week and the Canadian Council of Cardiovascular Nurses' spring nursing conference. Hospital administrative- and nursing-leaders assisted in distributing recruitment materials. A total of 410 nurses approached the research staff to participate in the study; screening was performed via email or telephone. Study measures were obtained from all eligible participants in each hospital by research staff.

2.3. Participants

Eligible participants were: 1) registered nurses or registered practical nurses actively working at one of the participating hospitals; 2) able to perform physical activity; 3) able and agreeable to wear an accelerometer at the waist for a 9-day recording period (a 9-day recording period was selected to cover all nursing schedule permutations); and, 4) able and willing to provide written, informed consent. Potential participants were excluded if they: 1) were unable to read and understand English or French; 2) had medical contraindications to moderate-to-vigorous intensity physical activity; or, 3) were currently pregnant or lactating.

2.4. Demographics and medical conditions

Research assistants collected information about participants' age, sex, and work characteristics (i.e. shift length, hospital area in which they worked at least 50% of their time, types of shifts, work status [full-time, part-time, or casual], and hospital location [rural or urban]). Participants were asked to complete a demographics and health questionnaire assessing ethnicity, marital status, level of education, annual income, smoking status, menstrual status, and medical conditions for which medications were being taken.

2.5. Cardiometabolic health

Height was measured to the nearest 0.1 cm, body mass was measured to the nearest 0.1 kg, and body mass index (BMI) was calculated (kg/m^2). Waist circumference was measured to the nearest 0.5 cm at the narrowest point of the torso (Seca 201) while participants stood with arms at their sides, feet together and abdomen relaxed (American College of Sports Medicine, 2017). Participants were asked to adhere to the following prior to their anthropometric measurements: 1) no eating or drinking for 4 h; 2) no moderate-to-vigorous intensity physical activity for 12 h; 3) no alcohol consumption for 48 h; 4) to void their bladder (within 30 min); 5) to refrain from consuming caffeine, and diuretic use unless prescribed by a clinician; and, 6) to postpone measurement if retaining water due to changes in menstrual cyclicity. Resting blood pressure and heart rate were measured using a Bp-TRU (Coquitlam, BC, Canada) or Mobil-o-graph (IEM Healthcare, Stolberg, Germany) as these are important indicators of cardiovascular risk (American College of Sports Medicine, 2017; Fox et al., 2007). All measures were performed in triplicate, and the average reported.

2.6. Cardiovascular risk

Participants' 5-year cardiovascular risk was calculated using the Harvard Score (Gaziano et al., 2008). This instrument has been shown to predict cardiovascular events as accurately as the Framingham Coronary Heart Disease Risk Score which requires laboratory-based values (Gaziano et al., 2008). Non-laboratory based risk factors (i.e. age, sex, diabetes status [no diabetes or diabetes], current smoking status [non-smoker or smoker], systolic blood pressure, and BMI) were used to determine the following 5-year cardiovascular disease risk (fatal and non-fatal) categories: < 5% (low); 5–10% (low); > 10–20% (moderate); > 20–30% (high); or, > 30% (high) (Gaziano et al., 2008). Cardiovascular risk scores were not calculated for participants with a systolic blood pressure < 111 mmHg or who were younger than 35 years of age – risk scores are not calculable for such individuals (Gaziano et al., 2008).

2.7. Physical activity

Physical activity levels were measured using objective and self-report data. Following anthropometric assessments, participants wore an ActiGraph GTX3 accelerometer (ActiGraph, Pensacola, Florida) over their right hip during waking hours for nine days, excluding periods when they engaged in water-related activities (i.e. bathing, swimming). The ActiGraph GT3X accelerometer is a lightweight, compact accelerometer that captures movement across three axes (y-, x- and z-axis), and has been shown to be valid and reliable across a range of physical activity intensities and modes (Migueles et al., 2017; Skotte et al., 2014). A composite measure of all three axes (vector magnitude = $\sqrt{(x^2 + y^2 + z^2)}$) was used. A 15-s sampling epoch was utilized and converted to counts-per-minute (cpm). Based on work performed by others, a valid day was defined as ≥10 h of wear-time, and participants were required to have a minimum of four valid days to be retained in the analyses (Colley et al., 2011). A day was based on a 24-h period to standardize physical activity analyses among nurses working varying shift lengths and types. A maximum of seven days of data was used; removing first and last days to reduce reactivity (i.e. social desirability) (Clemes and Deans, 2012). Previously validated vector magnitude cut-points were applied to define light (150–2690 cpm), moderate (2691–6166 cpm), and vigorous (≥6167 cpm) physical activity, and sedentary time (≤150 cpm) (Peterson et al., 2015; Sasaki et al., 2011). Wear-time was calculated by subtracting non-wear time from 24 h. Non-wear time was defined as at least 60 min of consecutive zeros for counts, with an allowance of up to two minutes of counts between zero and 150. Minutes spent in bouts of physical activity ≥10 min were used to quantify moderate-to-vigorous intensity physical activity per week consistent with the Canadian Society for Exercise Physiology and World Health Organization physical activity recommendation (≥150 min/week in bouts ≥10 min) (Canadian Society for Exercise Physiology, 2011; World Health Organization, 2011). A two minute interruption allowance was included in the 10 min physical activity bout definition (Troiano et al., 2008). Weekly average was calculated by multiplying the daily average (minutes/day) by seven. The ActiLife software was used to reduce the ActiGraph data; SAS v. 9.3 was then used to calculate the daily averages over seven days.

Participants completed the short form of the International Physical Activity Questionnaire (IPAQ) for comparison with objectively measured and self-report physical activity in nurses. Data from the short form IPAQ were summarized according to the physical activities (walking, moderate, and vigorous activities for at least 10 min at a time) recorded. The data was then used to estimate total daily moderate-to-vigorous physical activity by weighting the reported minutes per day within the moderate and vigorous physical activity categories (Craig et al., 2003). The short form vs. long form IPAQ was selected to reduce participant burden, and is recommended for national monitoring (Craig et al., 2003). The short form IPAQ has demonstrated acceptable test-retest reliability, with pooled data from 12 countries showing Spearman's rank correlation coefficients (rho) ranging from 0.32 to 0.88 for total physical activity (MET min/week) (Craig et al., 2003); it is, however, important to note that a correlation coefficient is not suitable to assess test-retest reliability as it is an indicator of association, not agreement (Zaki et al., 2013). Criterion validity of the short form IPAQ when compared to objective accelerometers (CSA model 7164) has been shown to possess fair to moderate agreement with ρ ranging from −0.12 to 0.57 for total physical activity (MET minutes/week) (Craig et al., 2003). Observed concurrent validity (inter-method) between the long and short form IPAQ suggests reasonable agreement, with ρ ranging from 0.45 to 0.85 for total physical activity (MET minutes/week) (Craig et al., 2003).

2.8. Perceived Workplace Environment Scale

Participants completed the Perceived Workplace Environment (PWE) scale which assesses employees' perceptions of their workplace environment's support for physical activity (Prodaniuk et al., 2004). The PWE scale is a validated tool developed in accordance with the ecological Workplace Physical Activity Assessment Tool (WPAAT) (Plotnikoff et al., 2005). A single item is used to assess perceptions associated with each environmental level of the ecological model of the WPAAT (i.e. individual, social, organization, policy, community, and physical environment) to provide a brief, six-item global measure of perceptions of the workplace ecological climate (e.g. How much information is provided in your workplace educating and/or encouraging employees about physical activity?). Participants responded to each item on a 5-point Likert scale anchored at the extremes by 1 (none) and 5 (a great amount); higher scores indicate a work environment perceived to be more supportive of physical activity. The PWE scale has been shown to possess good internal consistency reliability (Cronbach's Coefficient $\alpha = 0.83$) and stability (ICC = 0.97; $p < 0.01$) (Prodaniuk et al., 2004).

2.9. Statistical analysis

Using an effect size of 0.2 (i.e. small effect) according to Cohen's conventions, a sample size of 410 participants provides adequate power to detect significant differences in physical activity levels and cardiovascular health between two (1-β = 0.97) and up to six (1-β = 0.92) groups. All variables were tested for normality; sedentary time, moderate and vigorous intensity physical activity, steps, PWE scores and cardiometabolic health indicators (i.e. BMI, waist circumference, and systolic blood pressure) were not normally distributed. A two-step approach for transforming continuous variables to normal (Templeton, 2011) was applied to the physical activity variables. Analyses of covariance were performed to compare sedentary time, physical activity levels and steps between shift lengths, hospital areas, types of shifts, work status and hospital location groups. Hospital site and wear time were included as covariates as physical activity levels significantly differed by hospital site ($p < 0.05$) and may be biased towards how long a participant wore the accelerometer; significant values were adjusted by the Bonferroni correction for multiple comparisons. Hospital site was not, however, included as a covariate for the hospital location (i.e. urban vs. rural) analyses given that hospital location was the dependent variable. Mann-Whitney U tests were performed to compare PWE scores between types of shifts and hospital location groups, and Kruskal Wallis tests were performed to compare PWE scores between shift length, hospital area and work status groups. Spearman's rank-order correlation analyses adjusted for wear time were performed to examine the association across sedentary time, physical activity levels and PWE scores. Spearman's rank-order correlation analyses adjusted for wear time and age were performed to examine the association across sedentary time, physical activity levels and cardiometabolic health indicators. A two-step approach for transforming continuous variables to normal (Templeton, 2011) was applied to the BMI and waist circumference variables. Systolic blood pressure was normalized using the Ln arithmetic function. These normalized values were used for statistical analyses; however, non-normalized values are presented in the results for descriptive purposes. Analyses of covariance were subsequently performed to compare BMI, waist circumference and systolic blood pressure across shift lengths, hospitals areas, types of shifts, work status and hospital locations; the cardiometabolic health indicators were adjusted for age and sex as they were significantly associated with age and differed according to sex. The statistical level of significance was set at $p < 0.05$. Data are reported as means ± standard deviations unless otherwise noted. All data were analyzed using SPSS for Windows (version 24; IBM Corp, Armonk, NY, USA).

3. Results

A total of 410 nurses participated in this study. The number of nurses enrolled at each hospital and reasons for withdrawals are shown in Fig. 1. The proportion of nurses recruited from each hospital and the location of each hospital is shown in Fig. 2. Nurses' demographic, anthropometric and medical conditions are presented in Table 1. On average, nurses were revealed to be overweight, normotensive, and demonstrated a low-risk waist circumference (American College of Sports Medicine, 2017). Most (94%) were female, and several reported cardiovascular risk factors, including: poor mental health (depression: 9%, anxiety: 8%), smoking (8%), hypertension (7%), high cholesterol (4%), and diabetes (2%).

Five-year cardiovascular risk scores were calculated for a total of 180 nurses; scores for the remaining 230 of the total 410 nurses were not computed due to missing data (n = 8), or low systolic blood pressure (i.e. < 111 mmHg) or young age (i.e. < 35 years) (n = 222). Of the 180 nurses with cardiovascular risk scores, 117 (65%), 50 (28%) and 13 (7%) nurses had a low (< 10%), moderate (10–20%), and high (> 20%) risk of a fatal or non-fatal cardiovascular event in the next 5 years, respectively.

A total of 364 nurses (89%) wore the accelerometer for ≥10 h/day on at least four days for an average of 894 ± 102 min/day (~15 h/day). Nurses' sedentary time, and time spent in low, moderate and vigorous intensity physical activity, expressed as percentages of wear time, are shown in Fig. 3. The nurses spent an average of 445 ± 116 min/day in sedentary time, 408 ± 79 min/day in light intensity physical activity, 38 ± 18 min/day in moderate intensity physical activity, 3 ± 5 min/day in vigorous intensity physical activity. Analyses using bouts ≥10 min revealed that nurses accumulated 14 ± 14 min/day in moderate-to-vigorous intensity physical activity. This translated to an average of 288 ± 143 min/week in continuous moderate-to-vigorous intensity physical activity (not bouts), and an average of 96 ± 100 min/week in moderate-to-vigorous intensity physical activity in bouts of ≥10 min; 23% (n = 83) met the recommended physical activity guidelines. Nurses accumulated an average of 8176 ± 2351 steps/day and self-reported engaging in 123 ± 87 (median = 120) min/day in moderate-to-vigorous intensity physical activity using the IPAQ.

Table 2 presents minutes/day in sedentary time and light intensity physical activity, moderate intensity physical activity, vigorous intensity physical activity, moderate-to-vigorous intensity physical activity in bouts ≥10 min and steps according to shift lengths, hospital areas, types of shifts, work status and hospital location. When grouped according to shift lengths, significant differences in sedentary time ($F = 4.111$, $p = 0.017$), light intensity physical activity ($F = 7.163$, $p = 0.001$), moderate intensity physical activity ($F = 5.512$, $p = 0.004$) and moderate-to-vigorous intensity physical activity in bouts ≥10 min ($F = 3.223$, $p = 0.041$) were observed. Nurses working 8-h shifts accumulated fewer minutes/day in light intensity physical activity, and greater minutes/day in sedentary time, moderate intensity physical activity and moderate-to-vigorous intensity physical activity in bouts ≥10 min than those working 12-h shifts ($p < 0.05$). Nurses were drawn from several areas of the hospital (i.e. intensive care unit, post-anesthetic care unit, special care baby unit, labour and delivery [n = 66]; operating room [n = 22]; emergency room [n = 28]; surgery, medicine, long-term care, orthopedics, neurology, oncology, urology, floater [n = 161]; outpatient, mental health, imaging [n = 87]; and, administration, research [n = 41]). We consulted with nurses regarding their typical area-specific workload (i.e. nurse-to-patient ratio) and type of work performed in these areas to create the aforementioned groups. Significant differences in sedentary time ($F = 5.629$, $p < 0.001$), light intensity physical activity ($F = 6.402$, $p < 0.001$) and steps ($F = 2.595$, $p = 0.025$) were observed among the groups. Nurses in administration and research positions accumulated greater minutes/day in sedentary time, and fewer minutes/day in light intensity physical activity and daily steps ($p < 0.05$). Nurses reported working several types of shifts and combinations thereof (i.e. days [n = 175]; days and nights [n = 120]; days, nights and evenings [n = 30]; days and evenings [n = 28]; evenings [n = 5]; and, nights [n = 3]). These shift types were collapsed into fixed (i.e. straight days, evenings or nights) vs. rotating (i.e. days and nights; days, nights and evenings; days and evenings) shifts to maximize statistical power. When grouped according to types of shifts, nurses working fixed vs. rotating shifts accumulated greater minutes/day in sedentary time ($p = 0.002$), moderate intensity physical activity ($p = 0.020$) and moderate-to-vigorous intensity physical activity in bouts ≥10 min ($p = 0.022$), and fewer minutes/day in light intensity physical activity ($p < 0.001$). When grouped according to work status, significant differences in vigorous intensity physical activity ($F = 3.130$, $p = 0.026$) and moderate-to-vigorous intensity physical activity in bouts ≥10 min ($F = 4.760$, $p = 0.003$) were observed. Nurses working casually vs. full-time or part-time accumulated greater minutes/day in vigorous intensity physical activity and moderate-to-vigorous intensity physical activity in bouts ≥10 min ($p < 0.05$). Finally, no differences in sedentary time, light intensity physical activity, moderate intensity physical activity,

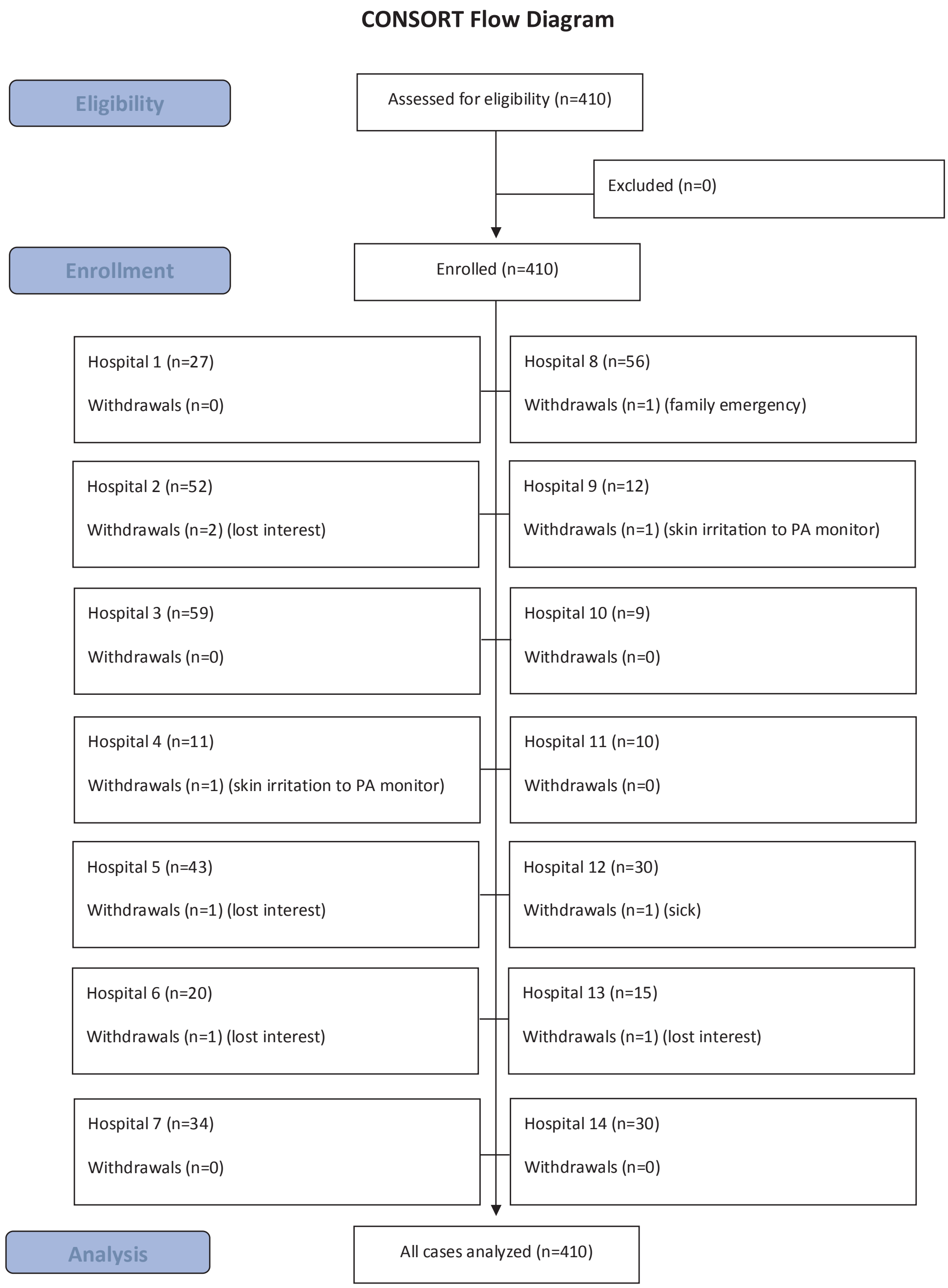

Fig. 1. CONSORT flow diagram of nurses recruited from each hospital and reasons for withdrawals. CONSORT, Consolidated Standards of Reporting Trials; PA, physical activity.

vigorous intensity physical activity, moderate-to-vigorous intensity physical activity in bouts ≥10 min or steps were observed between nurses working in rural vs. urban hospitals ($p > 0.05$).

The average PWE score was 2.4 ± 0.9. No significant associations across PWE scores and light, moderate or vigorous intensity physical activity, or steps were observed ($p > 0.05$). Table 3 presents the PWE scores as per shift lengths, hospital areas, types of shifts, work status and hospital location. When grouped according to shift lengths, significant differences in PWE scores were observed ($\chi^2 = 20.577$, $p < 0.001$). Significantly better PWE scores were observed by nurses working 8- vs. 12-h shifts ($p < 0.001$). When grouped according to hospital areas, significant differences in PWE scores were observed ($\chi^2 = 13.349$, $p = 0.020$). When grouped according to types of shifts, significantly better PWE scores were observed by nurses working fixed vs. rotating shifts ($p = 0.005$). No significant differences in PWE scores were observed among nurses working full-time, part-time or casual ($\chi^2 = 2.256$, $p = 0.521$). Significantly better PWE scores were observed by nurses working in urban vs. rural hospitals ($p = 0.030$).

Correlation analyses for sedentary time, physical activity levels, steps and cardiometabolic health outcomes are shown in Table 4. No significant differences in physical activity levels (i.e. light, moderate, or vigorous intensity physical activity) and steps were observed across cardiovascular risk score categories ($p > 0.05$).

No significant differences were observed across cardiometabolic health indicators (i.e. BMI, waist circumference, systolic blood pressure) by shift lengths, hospital areas or work status ($p > 0.05$). Nurses working fixed vs. rotating shifts had higher systolic blood pressure (median: 114 vs. 112 mmHg, $p = 0.043$), but nurses working fixed and rotating shifts were considered normotensive. Nurses working in rural vs. urban hospitals had higher BMI (median: 27.8 vs. 25.6 kg/m^2,

Hospitals	N (% from hospital)
Hospital 1	59 (3)
Hospital 2	56 (11)
Hospital 3	52 (3)
Hospital 4	43 (12)
Hospital 5	34 (6)
Hospital 6	30 (8)
Hospital 7**	30 (21)
Hospital 8	27 (7)
Hospital 9	21 (3)
Hospital 10**	15 (14)
Hospital 11**	12 (6)
Hospital 12	12 (5)
Hospital 13**	10 (3)
Hospital 14**	9 (18)

**, denotes a rural hospital in a community with a population < 30,000 and greater than a 30 minute drive to a community with a population >30,000

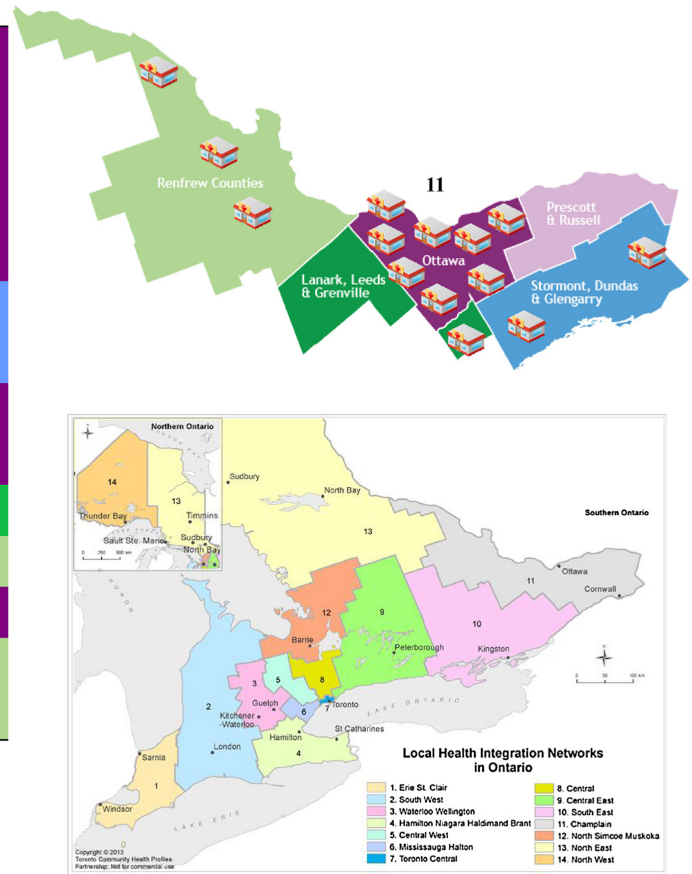

Fig. 2. Proportion of nurses recruited from each hospital in the Champlain region of Ontario. This figure has been reprinted with permission from the Ontario Community Health Profiles Partnership (http://www.ontariohealthprofiles.ca/).

F = 7.454, p = 0.007) and waist circumference (median: 82.3 vs. 78.6 cm, F = 5.913, p = 0.015), but not systolic blood pressure (p > 0.05). No differences were observed across cardiovascular risk score categories by shift lengths, hospital areas, types of shifts, work status or hospital location.

4. Discussion

This study is the first, to our knowledge, to objectively measure the physical activity and cardiometabolic health of a sample of Canadian hospital nurses. In this multi-centre, cross-sectional study, we observed that nurses spent the majority of their time being sedentary or engaging in light intensity physical activity. These findings are consistent with previous population level studies showing that moderate-to-vigorous intensity physical activity accounts for a small proportion of the day when compared to sedentary time and light intensity physical activity (Owen et al., 2014). Few (23%) nurses met the Canadian and World Health Organization physical activity guidelines (≥150 min/week in bouts of ≥10 min), yet they exceeded these recommendations when examining their continuous (i.e. non bouts) physical activity levels. Nurses working 8-h shifts, fixed shifts or casually accumulated greater moderate-to-vigorous intensity physical activity levels (bouts), while nurses working 8-h shifts, fixed shifts, in outpatient, mental health, imaging, administration and research, and in urban hospitals reported better PWE scores. A substantial number of nurses presented with and/or reported several cardiovascular disease risk factors (i.e. obese/overweight, poor mental health, smoking, hypertension, high cholesterol, and diabetes). Nurses working fixed vs. rotating shifts had higher systolic blood pressure, and nurses working in rural vs. urban hospitals had a higher BMI and waist circumference. Most had a low risk of having a fatal or non-fatal cardiovascular event in the next five years.

Several investigators in a variety of settings (e.g. Canada, United States, Iceland, Thailand, and Australia) have assessed the physical activity levels of nurses using self-report measures (James et al., 2013; Kaewthummanukul et al., 2006; Perry et al., 2015; Ratner and Sawatzky, 2009; Sveinsdottir and Gunnarsdottir, 2008); few have assessed the physical activity levels of nurses using objective measures including accelerometry, heart rate monitoring and direct observation (Babiolakis et al., 2015; Chappel et al., 2017). Caution must be used when interpreting previous findings as self-reported physical activity may be biased by issues of recall and social desirability, especially among women leading to over-estimations of physical activity (Prince et al., 2008). To overcome these issues, we objectively measured the physical activity of nurses from the Champlain region of Ontario, Canada. Using accelerometry data, nurses spent an average of 14 min/day and self-reported (IPAQ) engaging in 123 (median = 120) min/day of moderate-to-vigorous intensity physical activity in bouts of ≥10 min. Our findings are consistent with studies showing that self-report measures tend to overestimate physical activity levels when compared with objective assessments (Prince et al., 2008). We, therefore, must be cautious in assuming nurses are sufficiently physically active based on self-report measures. If using less strict physical activity guidelines (i.e. 150 min of moderate-to-vigorous intensity physical activity with no restriction on bout length), our nurses accumulated 288 min/week of moderate-to-vigorous intensity physical activity. Such physical activity levels along with a daily average of 8176 steps suggests our nurses were physically active, and more so than the general population (Colley et al., 2011) and other occupational groups (e.g. transit workers, office

Table 1
Participant characteristics (N = 410).

	All participants N = 410	Females n = 387	Males n = 23
Demographics and anthropometrics	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Age (years)	42.9 ± 11.9	43.1 ± 11.9	40.7 ± 10.4
Sex (% female)	94%	94%	–
Ethnicity (% white)	86%	87%	78%
Marital status (% married)	67%	67%	70%
Education (% University bachelor's degree)	47%	47%	44%
Personal annual income (% $75,000–$99,999)	46%	46%	35%
Smoker (%)	8%	8%	9%
Premenopausal (%)	72%	72%	–
Height (cm)	164.5 ± 6.5	163.9 ± 6.0	174.4 ± 7.5
Body mass (kg)	73.3 ± 15.0	72.7 ± 15.0	84.0 ± 10.2
BMI (kg/m^2)	27.1 ± 5.4	27.1 ± 5.5	27.7 ± 3.6
Waist circumference (cm)	80.8 ± 11.8	80.3 ± 11.8	89.2 ± 7.7
Resting systolic blood pressure (mmHg)	114 ± 12	114 ± 12	119 ± 14
Resting diastolic blood pressure (mmHg)	74 ± 9	74 ± 9	78 ± 12
Resting heart rate (bpm)	69 ± 10	69 ± 10	64 ± 9
Medical conditions[a]	**n (%)**	**n (%)**	**n (%)**
Musculoskeletal pain, injury or repair	68 (16.7)	61 (15.9)	7 (30.4)
Depression	35 (8.6)	33 (8.6)	2 (8.7)
Anxiety	33 (8.1)	31 (8.1)	2 (8.7)
Asthma	32 (7.8)	30 (7.8)	2 (8.7)
Hypertension	30 (7.4)	29 (7.5)	1 (4.3)
Hypothyroidism	23 (5.6)	23 (6.0)	–
Gastrointestinal issues (e.g. GERD, gastritis, Crohn's)	22 (5.4)	21 (5.5)	1 (4.3)
Arthritis	18 (4.4)	18 (4.7)	–
Sleep disorders (e.g. sleep apnea, insomnia, restless leg)	17 (4.2)	16 (4.1)	1 (4.3)
Dyslipidemia	16 (3.9)	16 (4.2)	–
Headaches or migraines	14 (3.4)	14 (3.6)	–
Diabetes	8 (2.0)	8 (2.1)	–
Skin disorders (psoriasis, eczema, dermatitis)	8 (2.0)	7 (1.8)	1 (4.3)
Allergies	7 (1.7)	7 (1.8)	–
Osteoporosis	4 (1.0)	4 (1.0)	–
Anemia	4 (1.0)	4 (1.0)	–
Hormonal therapy	4 (1.0)	4 (1.0)	–

BMI, body mass index; GERD, gastroesophageal reflux disease; SD, standard deviation.

[a] Only medical conditions for which more than 1.0% of participants were taking medications are reported. Only the most frequently reported ethnicity, marital status, level of education and personal annual income are reported.

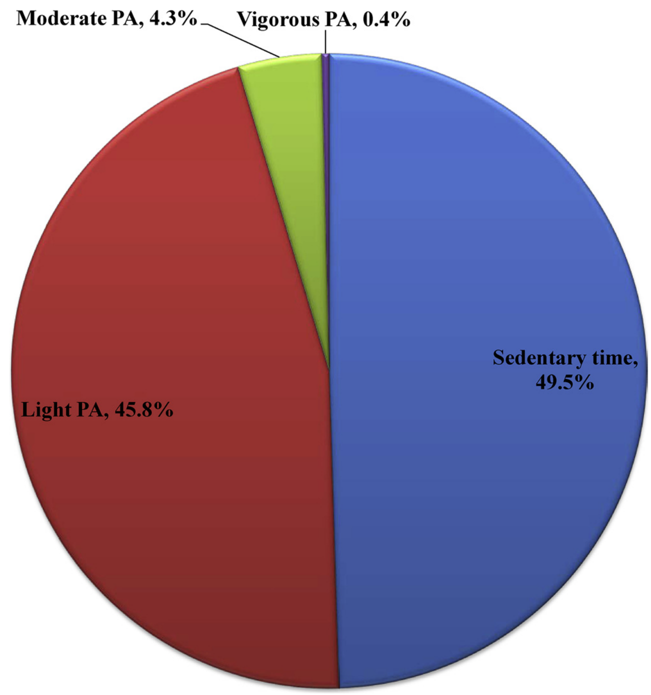

Fig. 3. Average proportion of time nurses spent engaging in sedentary time, and light, moderate and vigorous intensity physical activity expressed as percentages of wear time. PA, physical activity.

workers) (French et al., 2007; Jancey et al., 2016). It is important to note that the current physical activity guidelines are largely based on the total volume of physical activity accumulated and associations with health. There is strong evidence to suggest that accumulated minutes of moderate-to-vigorous intensity physical activity (bouts < 10 min) confers consistent health benefits (Glazer et al., 2013; Loprinzi and Cardinal, 2013; Warburton and Bredin, 2017; Wolff-Hughes et al., 2015). It is, therefore, important that studies reporting on physical activity levels clearly state their measurement criterion as this substantially impacts how nurses and other occupational groups' physical activity levels are interpreted, and potentially resource allocation for physical activity interventions for at risk populations.

Nurses in our sample accumulated an average of 14 min/day of moderate-to-vigorous intensity physical activity in bouts ≥10 min, and 23% met current physical activity guidelines. Our objective physical activity levels can be compared to those of Canadian women; objective data from the 2007 to 2009 Canadian Health Measures Survey (CHMS) showed that females aged 40–59 years (comparable to our predominately female sample who was on average 47 years of age) accumulated an average of 21 min/day of moderate-to-vigorous intensity physical activity in bouts ≥10 min, and 14% met the current physical activity guidelines (Colley et al., 2011). There are likely several multi-level factors which contributed to the low physical activity levels (when low is defined as not meeting the current Canadian and World Health Organization physical activity guidelines) observed among our nurses (Kaewthummanukul et al., 2006; Prince et al., 2016). It is known that moderate-to-vigorous intensity physical activity levels among working-age women are directly affected by self-efficacy, self-rated health, perceived behavioural control, and having children (Adamo et al., 2012; Prince et al., 2016). Perceptions of physical activity, self-efficacy, social support and motivation to engage in physical activity have been shown to be barriers to physical activity participation among Taiwanese nurses (Kaewthummanukul et al., 2006). Further, decentralized nursing stations which result in shorter distance between stations and patient beds may decrease physical activity levels (Zborowsky et al., 2010). Future investigations might usefully explore the intrapersonal, social- and physical-environmental determinants of moderate-to-vigorous intensity physical activity influencing Canadian nurses so that appropriate, tailored interventions to address suboptimal physical activity levels might be developed and delivered.

Several investigators have examined nurses' occupational physical activity levels (Chappel et al., 2017; Steeves et al., 2015). Using accelerometry data from the National Health and Nutrition Examination Survey (NHANES), investigators identified "health diagnosing, assessing and treating" and "health service" nursing activities as having low and intermediate levels of occupational physical activity, respectively (Steeves et al., 2015). A recent systematic review found that nurses spent the majority of their shifts engaged in light intensity physical activity which was interspersed with frequent moderate intensity nursing tasks, regardless of shift length or type (Chappel et al., 2017). Further, this review found that moderate-to-vigorous intensity physical activity levels were high and nurses achieved the recommended physical activity guidelines through their occupational physical activity (Chappel et al., 2017). Although we did not assess occupational physical activity specifically, our nurses spent a substantial amount of their

Table 2
Minutes per day in sedentary time and physical activity levels, and steps per day as measured by objective accelerometers according to shift lengths, hospital areas, types of shifts, work status, work status and hospital location.

	Sedentary time Mean ± SD	Light PA Mean ± SD	Moderate PA Mean ± SD	Vigorous PA Mean ± SD	MVPA bouts Mean ± SD	Steps Mean ± SD
Shift lengths						
8 h	450.7 ± 111.8*	395.3 ± 80.4*	39.8 ± 18.1*	3.3 ± 5.7	15.6 ± 16.0*	8160.3 ± 2506.8
12 h	443.1 ± 128.6	430.1 ± 71.3	34.2 ± 18.8	2.9 ± 4.4	10.4 ± 10.9	8110.1 ± 1915.5
8 and 12 h	416.5 ± 78.8	413.7 ± 77.8	38.6 ± 17.2	4.4 ± 6.5	13.7 ± 11.9	8533.6 ± 2515.8
Hospital areas						
ICU, PACU, SCBU, labour and delivery	443.0 ± 142.6*	410.9 ± 80.1*	35.6 ± 17.4	3.7 ± 5.2	13.5 ± 12.1	7871.1 ± 2116.0
OR	424.4 ± 96.8*	435.6 ± 81.0*	42.2 ± 20.5	4.3 ± 5.7	17.8 ± 17.1	9023.3 ± 2595.8
ER	424.4 ± 96.9*,†	435.6 ± 81.0*,†	42.2 ± 20.5	4.3 ± 5.7	17.8 ± 17.1	9286.8 ± 2121.1*,‡
Inpatient	440.4 ± 113.3*	417.8 ± 80.8*	36.0 ± 19.3	2.9 ± 5.3	12.0 ± 14.2	8077.7 ± 2334.8
Outpatient, mental health and imaging	457.0 ± 112.8	395.4 ± 68.3	39.8 ± 15.8	3.2 ± 5.3	15.8 ± 14.7	8287.3 ± 2236.5
Administration and research	495.2 ± 96.0	357.5 ± 70.3	42.7 ± 18.4	3.2 ± 5.0	16.6 ± 16.4	7693.8 ± 2524.8
Types of shifts						
Fixed	453.6 ± 114.3*	392.2 ± 77.9*	39.4 ± 17.1*	3.3 ± 5.4	15.5 ± 15.0*	8112.0 ± 2476.0
Rotating	435.5 ± 115.2	425.4 ± 76.2	36.3 ± 19.6	3.1 ± 5.4	11.8 ± 13.2	8254.0 ± 2169.2
Work status						
Full-time	447.7 ± 119.6	407.4 ± 79.6	37.5 ± 18.1	3.3 ± 5.7*	13.4 ± 14.6*	8175.2 ± 2324.2
Part-time	441.4 ± 109.1	408.6 ± 69.4	37.4 ± 18.7	2.4 ± 3.8*	13.0 ± 11.8*	7974.4 ± 2176.1
Casual	427.3 ± 82.0	403.7 ± 123.2	47.9 ± 19.3	8.2 ± 6.4	28.7 ± 16.7	9721.2 ± 3036.7
Full-time and part-time	413.4 ± 77.0	466.5 ± 135.9	47.2 ± 24.1	3.4 ± 4.8	5.6 ± 7.9	8393.5 ± 2325.2
Hospital location						
Rural	439.0 ± 125.8	421.2 ± 80.8	38.8 ± 23.3	2.5 ± 3.7	10.4 ± 10.7	7924.7 ± 2404.1
Urban	446.8 ± 113.8	405.1 ± 78.3	37.6 ± 17.1	3.5 ± 5.7	14.5 ± 14.8	8230.1 ± 2304.2

ER, emergency room; ICU, intensive care unit; MVPA, moderate-to-vigorous intensity physical activity; OR, operating room; PA, physical activity; PACU, post-anesthesia care unit; SCBU, special care baby unit; SD, standard deviation.
Shift lengths: *, $p < 0.05$ 8 h vs. 12 h. Hospital areas: *, $p < 0.05$ ICU, PACU, SCBU, labour and delivery; OR; ER; or, inpatient vs. administration and research. †, $p < 0.05$ ER vs. outpatient, mental health and imaging. ‡, $p < 0.05$ ER vs. ICU, PACU, SCBU, labour and delivery. Types of shifts: *, $p < 0.05$ fixed vs. rotating. Work status: *, $p < 0.05$ full-time or part-time vs. casual.

Table 3
Perceived Workplace Environment scores according to shift lengths, hospital areas, types of shifts, work status and hospital location.

	PWE scores Mean ± SD
Shift lengths	
8 h	2.5 ± 0.9*
12 h	2.1 ± 0.8
8 and 12 h	2.4 ± 1.0
Hospital areas	
ICU, PACU, SCBU, labour and delivery	2.3 ± 0.8*
OR	2.4 ± 1.1
ER	2.5 ± 0.9
Inpatient	2.2 ± 0.8*,†
Outpatient, mental health and imaging	2.6 ± 0.9
Administration and research	2.6 ± 0.8
Types of shifts	
Fixed	2.5 ± 0.9*
Rotating	2.2 ± 0.8
Work status	
Full-time	2.3 ± 0.9
Part-time	2.4 ± 0.8
Casual	2.8 ± 1.1
Full-time and part-time	2.0 ± 0.0
Hospital location	
Rural	2.2 ± 1.0
Urban	2.4 ± 0.8*

ER, emergency room; ICU, intensive care unit; OR, operating room; PACU, post-anesthetic care unit; PWE, perceived workplace environment; SCBU, special care baby unit; SD, standard deviation.
Shift lengths: *, $p < 0.05$ 8 h vs. 12 h. Hospital areas: *, $p < 0.05$ ICU, PACU, SCBU, labour and delivery; or, inpatient vs. outpatient, mental health and imaging. †, $p < 0.05$ inpatient vs. administration and research. Types of shifts: *, $p < 0.05$ fixed vs. rotating. Hospital location: *, $p < 0.05$ urban vs. rural.

time engaging in light intensity physical activity. It is, therefore, most likely that their moderate-to-vigorous intensity physical activity was accumulated outside of the workplace. It is also plausible to assume that nurses working 8-h shifts, fixed shifts and casual hours had a greater number of opportunities to engage in moderate-to-vigorous intensity physical activity outside of the workplace due to more flexible hours and schedules. Our findings support this postulation as better PWE scores were observed by nurses working 8-h and fixed shifts. Previous studies have shown rotating shifts to be associated with fewer physical activity opportunities (Atkinson et al., 2008). Nurses who are fatigued due to shift work and long work hours may be less likely to participate in physical activity and other health behaviours when not working (Caruso, 2014).

Our findings suggest that interventions are needed to address the low physical activity levels of at risk Canadian nurses, particularly for those working 12-h shifts, rotating shifts, full-time and part-time. Workplaces have been suggested as an ideal environment to educate, promote and encourage physical activity given adults spend a substantial proportion of their waking hours in the workplace (Clemes et al., 2014). Our recent systematic review and meta-analysis of workplace interventions designed to increase physical activity levels demonstrated they produced variable improvements in moderate-to-vigorous intensity physical activity levels and related cardiometabolic outcomes among working-age women (Reed et al., 2017). Workplace interventions significantly increased minutes/week of metabolic equivalents (210 MET minutes/week) (Reed et al., 2017). Several investigators have also shown that workplace interventions are effective in reducing sedentary time (Chu et al., 2016). Previous interventions largely focused on creative strategies (e.g. changes to nursing schedules, promotion of active breaks, reimbursement for recreation/fitness memberships, redesign of hospitals to encourage taking the stairs, active transportation infrastructure, childcare provisions for after hours, retail food reform in hospitals) to improve employees' physical activity

Table 4
Spearman's partial rank correlation coefficients (*p*-value) with sedentary time, physical activity levels, steps and cardiometabolic health sequelae controlling for age and wear time.

Objectively measured sedentary time, PA levels and steps	Systolic blood pressure ρ (p-value)	Waist circumference ρ (p-value)	Body mass index ρ (p-value)
Sedentary time (minutes/day)	0.084 (0.110)	0.163 (0.002)*	0.152 (0.004)*
Light intensity PA (minutes/day)	−0.083 (0.117)	−0.167 (0.001)*	−0.167 (0.001)*
Moderate intensity PA (minutes/day)	0.016 (0.756)	0.025 (0.638)	0.040 (0.453)
Vigorous intensity PA (minutes/day)	−0.052 (0.325)	−0.210 (< 0.001)*	−0.210 (< 0.001)*
Steps (number/day)	−0.107 (0.042)	−0.212 (< 0.001)*	−0.198 (< 0.001)*
MVPA (minutes/week)	0.041 (0.796)	−0.031 (0.559)	−0.018 (0.731)
MVPA in bouts (minutes/week)	−0.039 (0.463)	−0.137 (0.009)*	−0.130 (0.013)*

MVPA, moderate-to-vigorous intensity physical activity; PA, physical activity.
* $p < 0.05$.

levels and health; the effectiveness of such strategies have shown modest improvements (Curry, 2012; Dojeiji et al., 2017). Shifts in workplace culture are needed to improve nurses' physical activity levels and subsequently cardiometabolic health.

It is well known that regular physical activity is associated with optimal cardiovascular, bone and mental health, and forestalling premature death (Baillot et al., 2015; Haskell et al., 2007; Martyn-St James and Carroll, 2010; Reed and Pipe, 2016; Warburton et al., 2010, 2006). On average, nurses in our study appear to have lower blood pressure, cholesterol and glucose levels known to lower risk. It is reasonable to assume that their continuous (i.e. non bouts) moderate-to-vigorous intensity physical activity levels, though well below guideline recommendations (i.e. 14 min/day of moderate-to-vigorous intensity physical activity in bouts ≥10 min; 8176 steps/day), mitigate the presence of these cardiovascular disease risk factors (Oguma and Shinoda-Tagawa, 2004; Tudor-Locke et al., 2011). As our nurses spent a substantial proportion of their time engaging in light intensity physical activity, it is likely that such intensity also conferred health benefits (Howard et al., 2015). Further, it is also possible that our nurses' younger age and premenopausal status protected against cardiovascular disease risk factors (Mendelsohn, 2002). We must interpret our findings, however, with caution as cholesterol, diabetes, and mental health status were self-reported. Further, several nurses (7%) reported taking medications to manage hypertension, which likely contributed to the lower prevalence of nurses with high blood pressure.

Although our nurses, on average, appear to have good cardiometabolic health, a surprising number were overweight/obese (58%) and smokers (8%); had a waist circumference associated with health risks (24%) and high blood pressure (7%); and, were taking medications to manage depression (9%), anxiety (8%), high cholesterol (4%) and diabetes (2%). The proportion of the nurses who were overweight/obese and smokers also appears to be comparable to Canadian women. Results from the CHMS indicate that a substantial number of Canadian women are overweight or obese (> 50%); have a high risk waist circumference (41%), high blood pressure (17%) and high levels of low-density lipoprotein (LDL) (16%); are living with diabetes (6%); and, suffer from depression (6%) and anxiety (3%) (Public Health Agency of Canada, 2011; Statistics Canada, 2013a, 2013b, 2015, 2014, 2012). In Canada 10% of adult women smoke (Reid et al., 2017). Excess weight and smoking are independently associated with several chronic diseases, including cardiovascular diseases, respiratory diseases, diabetes and cancers, and continue to be critical priorities for cardiovascular disease and cancer prevention (Guh et al., 2009; Must et al., 1999; U.S. Department of Health and Human Services, 2014). The proportion of the nurses in our sample suffering from depression and anxiety exceeds that of Canadian women (Statistics Canada, 2015). Our findings are consistent with previous studies examining the mental health of nurses (Shields and Wilkins, 2006), and not surprising given the mental and physical demands that accompany nursing practice (Chin et al., 2016). Appropriate lifestyle interventions targeting sleep, physical activity, healthy eating, smoking cessation and stress management offer the opportunity to improve the mental and cardiometabolic health of Canadian nurses (Caruso, 2014; Rebar et al., 2015). Workplace interventions have also been shown to significantly decrease body mass (−0.83 kg), BMI (−0.35 kg/m^2), LDL (−0.11 mmol/L), and blood glucose (−0.18 mmol/L) and may offer opportunities to reduce these risk factors (Reed et al., 2017). Recent systematic reviews by our research team on the intrapersonal, social and physical environmental determinants of moderate-to-vigorous intensity physical activity in working-age women (Prince et al., 2016), and correlates of sedentary behaviours in adults (Prince et al., 2017) also serve to inform intervention development to target low physical activity levels and poor cardiometabolic health of at risk nursing populations.

Our work provides a contemporary, reliable research base for policy makers and stakeholders including hospital administrators and occupational health departments to support the need, design and implementation of mental health screening for nurses and appropriate organizational interventions to support positive health behaviours (e.g. physical activity, healthy eating, smoking cessation, stress management). Such work is critical as cardiovascular disease, and physical inactivity have been shown to be related to lower ability to work and greater incidence of absenteeism; a costly outcome for employers (Burton et al., 2014; van den Berg et al., 2017). We must take care of those who take care of us!

Nurses reach a large proportion of the population making them an integral part of the health workforce. A systematic review showed that nurses with positive attitudes towards physical activity and high levels of physical activity were more likely to promote physical activity to their patients when compared with inactive nurses (Fie et al., 2013). It is, therefore, reasonable that appropriate interventions are not only designed and implemented to increase and maintain nurses' physical activity levels, but also their cited barriers (i.e. lack of time, financial incentives and resources, discomfort in providing physical activity-related advice, insufficient training and education on physical activity, absence of a systematic approach and protocols) to promoting physical activity within their clinical practices so that all health care contacts can maximize the opportunities to promote active living (Bakhshi et al., 2015).

Our study has several strengths. It is the first study to objectively measure the physical activity levels of a large sample of Canadian nurses from a blend of rural and urban hospitals. This is particularly important as women tend to over-report their physical activity levels to a greater degree than men (Prince et al., 2008); the majority of nurses in the current study were female. Second, the influence of workplace characteristics (i.e. hours, shifts, work status, hospital and area location, perceived workplace physical activity environment) on nurses' physical activity levels and cardiometabolic health was thoroughly assessed. Finally, we recruited nurses over 14 months, ensuring a distribution of sampling across seasons (spring: n = 135; summer: n = 74; fall: n = 90; winter: n = 111) (Tucker and Gilliland, 2007). Several limitations warrant mention. First, the generalizability of our findings to male nurses is limited as 94% of our sample were females – characteristic of the Canadian nursing population (Shields and Wilkins, 2006). Further, the generalizability of our findings to older nurses and those working nights only is limited, given most of our nurses were premenopausal and working days only. Second, this was a cross-sectional study which did not assess the nurses' physical activity levels or cardiometabolic health over time. Third, the workplace environment for supporting physical activity was assessed using a subjective self-report questionnaire; we did not observe an association between PWE scores and moderate-to-vigorous intensity physical activity levels. Future studies could perform hospital audits to objectively assess available resources and facilities for physical activity opportunities; there is limited data on the impact of the work environment on sedentary behaviours and physical activity levels (Prince et al., 2016, 2017). Fourth, we recruited 3–21% of nurses from the sampled hospitals; it is possible that nurses interested in participating in a physical activity and health study may be 'healthier' and more active than average. Fifth, the usefulness of the cardiovascular disease risk scores was limited as these scores are largely influenced by age, and many of our nurses were younger than 35 years for which scores are not available. Sixth, we used a single PWE score to determine the physical activity environments of the hospitals. This is a subjective tool and may be skewed by what the nurses perceived to be available versus what is actually available (Ball et al., 2008). Future studies might usefully compare physical activity with objectively measured workplace physical activity environmental features. Seventh, information concerning the length of time that nurses had been working in the hospital setting, or as a nurse overall, was not collected. Such information may be an important moderating factor. Eighth, physical activity levels during work vs. non-work hours and mode of physical activity were not assessed; this information would assist in the development of physical activity interventions. Ninth, reliability estimates for the psychometric tools (i.e. PWE scale and IPAQ) used in the current study were not reported as this was a cross-sectional study with one measurement period. Tenth, we did not obtain each nurse's work schedule to customize our physical activity analyses per shift length and type. A day was based on a 24-h clock to standardize our physical activity analyses. Finally, while the accelerometers primarily rely on movements such as walking, we used tri-axial accelerometers which are able to capture movement across the x- y- and z-direction axes. Unfortunately, they are limited as they are unable to completely capture activities such as swimming and cycling or more arm-based movements

5. Conclusions

Hospital nurses do not appear to be meeting current physical activity guidelines, but exceeded the recommendations if evaluating continuous (i.e. non bout) physical activity levels. Rotating shifts, 12-h shifts, and/or working full-time or part-time hours may prevent nurses from meeting the recommended levels of physical activity. Novel and multi-faceted interventions are needed to address low physical activity levels and poor cardiometabolic health of at risk Canadian nurses.

Ethics approval

Local research ethics committees approved all aspects of each survey and all participants gave written informed consent.

Consent for publications

Not applicable.

Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author and the University of Ottawa Heart Institute on reasonable request.

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Authors' contributions

JLR and RDR obtained funding, conceptualized and designed the study. JLR performed the analyses and interpretation of the data, drafted the initial manuscript, and revised and approved the final manuscript as submitted. SAP assisted with the data analysis and interpretation, provided critical revision of the manuscript, and approved the final manuscript as submitted. SA assisted with the acquisition of data, provided critical revision of the manuscript, and approved the final manuscript as submitted. ALP, KBA, KAM, HET, DM and GF provided critical revision of the manuscript, and approved the final manuscript as submitted.

Competing interests

The authors declare that they have no competing interests.

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