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Quantitative Assessment of Occupational and Leisure-Time Physical Activity and Sedentary Behavior in Registered Nurses and Certified Nursing Assistants Using Wrist-Worn Accelerometers

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Clinical significance

The results of this research highlight the importance of understanding how job roles affect physical activity in nurses. The accurate quantification of occupational and leisure-time activity can guide tailored health strategies, reduce sedentary behavior, and promote optimal physical activity levels, ultimately enhancing nurse well-being and potentially improving patient care outcomes.

Abstract

Objective: This study aimed to explore how occupational physical activity (OPA) and leisure-time physical activity (LTPA) interact with nurses assigned to different roles (i.e., registered and assistants)

Methods: Twenty-two professional nurses were monitored for 7 days, using a wearable accelerometer. Based on raw data, PA was classified as sedentary behavior (SB), light, moderate, and vigorous intensity PA (LPA, MPA, VPA)

Results: In comparison with registered nurses, certified nursing assistants spent less time in SB (29% vs. 53%), and more time in MPA (20% vs. 8.8%) and VPA (20.5% vs. 9.1%) during working shifts. In contrast, LTPA levels were similar across the groups (~30%). Associations between OPA and LTPA differed by role.

Conclusion: Among nurses, job roles shape the OPA–LTPA relationship. Measuring PA provides essential evidence for designing workplace interventions that promote balanced activity and recovery.

Keywords

Occupational health; Activity Tracker; Workplace, Healthcare

Bulleted Learning Outcomes

- Compare and interpret the levels of occupational and leisure-time physical activity (PA) and sedentary behavior (SB) levels among registered nurses and certified nursing assistants, using accelerometer-derived data collected over 7 days.
- Evaluate the relationship between occupational and leisure-time PA intensities (LPA, MPA, VPA) within each job role to understand how work-related demands influence non-work activity patterns.
- Recognize the impact of the occupational demands on leisure-time behaviors in nursing populations to improve the design of workplace interventions that promote balanced activity and recovery.

1. Introduction

The healthcare sector employs the largest workforce globally, with nurses accounting for approximately 48% of this population[1]. They usually perform a wide range of physically demanding tasks[2], which require substantial muscular effort, particularly those related to patient care, such as assisting with mobility, hygiene, ambulation, and postural transitions. Also quite common are prolonged standing, walking, and manual handling of tools and devices[3]. Such a challenging work environment can be exacerbated by shift work, which can vary in both duration (i.e., <8h; 8-12h; >12h) and pattern (i.e., standard office hours; day only, rotating including evening; rotating including night) [4].

Given these peculiar aspects, researchers and practitioners demonstrated significant interest in accurately assessing the physical demands of nurses' working tasks, to protect nurses' health and job retention, reduce healthcare costs, and enhance the quality of patient care[2]. In this context, particular attention has been paid to the analysis of occupational physical activity (OPA), that is, the physical activity (PA) performed during working hours, which is now considered just like any other occupational exposure amenable to measurement and modification[5].

In fact, although it is widely acknowledged that engaging in an active lifestyle yields benefits for health and well-being, including reduced risk for chronic disease and improved psychosocial health outcomes [6,7], a body of work has emerged, over the last decade, which suggest that OPA and leisure-time PA (LTPA) are likely to providing different (and often non concurrent) effects on health[8,9].

Although numerous studies have reported data on OPA among nurses, these data often derive from secondary study objectives, tend to overlook LTPA, and yield mixed findings[2]. For instance, the number of steps per shift varies widely across care units (from 616 to 17,240),[10-14] and similar variability is observed in the proportion of time spent in light and moderate PA (LPA, MPA). Studies employing quantitative measures (e.g., accelerometers and heart rate monitors) indicate that nurses spend approximately 5–7% of their working shift in MPA and about 60% in LPA[15-18], while data derived by questionnaires indicated that nurses spend most of the working shift (up to 70%) in MPA[2]. Such discrepancies are likely due to heterogeneity in terms of the measurement tool (e.g., questionnaires, accelerometers, heart rate monitors), analyzed shift (e.g., day, night, rotating shift), and nursing roles (e.g., nursing aids, registered nurses, emergency room nurses) [2]. Moreover, it should be stressed that while the detrimental effect of high-intensity OPA in male-dominated occupations on cardiovascular health is well established[8,19], the body of evidence is limited for female-dominated occupations[8]. However, a recent systematic review reported that, while LTPA is associated with cardiovascular benefits in healthcare workers, OPA is not, thus suggesting they should be studied separately in this population[20].

Still, the literature investigating the role of OPA and LTPA as well as their potential links, is limited and yields contrasting results. For instance, Ekenga et al. [21] from the analysis of self-reported data of more than 27,000 working women found that those employed in occupations characterized by a reduced amount of OPA were less prone to engage in LTPA compared to those who performed more physically demanding occupations. A similar pattern was reported by Lallukka et al.[22] who, based on questionnaire data, found that physically demanding OPA was associated with higher levels of LTPA among women—likely reflecting greater motivation related

to enhancing attractiveness, muscle tone, and body weight management[23]. Other studies have shown that high levels of OPA result in less time spent in LTPA[8]. At last, Chin et al., [24] who examined the relationship between occupational factors and LTPA in a nursing workforce, found that high job demand was associated with regular aerobic LTPA. In contrast, Chappel et al. [25] reported no association between OPA and LTPA in emergency nurses according to quantitative data extracted from accelerometers.

The use of self-reported measures of physical behavior could probably explain part of these differences. Ukumoro and colleagues [26] – which assessed PA using both questionnaire and accelerometers – found that workers overreported minutes of MPA by nearly sevenfold compared to the accelerometric output; whereas, outside of work, the self-reported minutes of MPA were only 40% higher than those measured using an accelerometer. Moreover, most survey items commonly included in PA questionnaires focus on leisure-time activities and, as such, may not be well suited for assessing OPA.

To, at least partially, address the limitations in previous assessments of PA among nurse populations — such as biases associated with self-reported measures, variability due to undefined or mixed nursing roles, and the frequent neglect of distinguishing between OPA and LTPA —, this study aimed to quantitatively characterize PA patterns using wrist-worn accelerometers over an entire week. Specifically, we examined nurses employed in different roles (i.e., registered nurse and certified nursing assistant) and across various work shifts (i.e., morning, evening) to investigate whether, and to what extent, levels of OPA are associated with those of LTPA.

2. Methods

2.1. Participants

Twenty-two professional nurses (17 females, 5 males), all full-time employees at the University Hospital of Cagliari, Italy, participated voluntarily in the study. Participants were recruited from the general surgery, endoscopy, and orthopedic wards and were stratified into two categories based their professional role, namely: "registered nurses" and "certified nursing assistants". Registered nurse duties mainly include supervising and guiding staff, planning, developing, and implementing care plans, administering medications, and treatments. Instead, certified nursing assistants are responsible for patient care activities (e.g., provision of hygienic care, meal distribution, changing bed sheets, patient transportation, etc.)[27] Participants of both groups worked on rotating shifts (i.e., morning 7:00 a.m. – 2:00 p.m.; evening 2:00 p.m. – 10:00 p.m.).

The study was promoted and supported by the Health and Safety division of the Hospital and carried out in compliance with the ethical principles for research involving human subjects expressed in the Declaration of Helsinki and its later amendments. Formal approval was granted from the Ethics Commission of the of the University of Cagliari (UniCa - Prot. n. 0112541, 01/06/2023).

Before data collection, all participants provided written informed consent after receiving a detailed explanation of the study's purpose and methodology. Subsequently, they participated in a structured interview during which demographic and anthropometric data were obtained (see Table 1).

2.2. Data collection and processing

All participants were required to wear a triaxial accelerometer (GT9X, ActiGraph, Pensacola, USA) for 7 consecutive days, 24h per day, on their non-dominant wrist, removing it only during water-based activities (e.g., showering and swimming). Data were collected at 30 Hz, downloaded into 60-second epochs using ActiLife software v.6.13.4 (Acticorp Co., Pensacola, USA). Raw data was processed using ActiLife software to obtain (1) an overall measure of activity in terms of vector magnitude counts (VMC) (equation 1)

$$VMC = \sqrt{a_x^2 + a_y^2 + a_z^2} \qquad \text{equation 1.}$$

where a_x, a_y, a_z represent linear accelerations along the three orthogonal axes of motion, (2) the number of steps travelled; (3) minutes and percentage of time spent in sedentary behavior (SED, ≤1.5 METs), light- (LPA, 1.6-1.9 METs) moderate (MPA, 3.0-5.9 METs) and vigorous intensity (VPA, ≥6.0 METs) PA using previously validated cut-points [28]. All data were analyzed distinguishing between working hours and leisure-time. Working hours were defined as hours spent in the primary occupation (data obtained from hospital records) and leisure-time was defined as waking time (obtained from Actilife software v.6.13.4, Acticorp Co., Pensacola, USA) not at work. While treating all non-working activity as leisure-time represents an oversimplification of the phenomenon, this approach was chosen to minimize participant burden. Only workers having at least 5 working days of valid accelerometer measurements were included in the analysis. A valid day was defined as having at least 75% of the working hours and leisure-time data recorded [29].

2.3. *Statistical analysis*

The statistical analysis was designed to address the following research questions:

- Do PA amounts and
- al analysis found a significant main effect of both Group [F= 27.565, $\eta^2 = 0.269$, $p<0.001$], PA type [F= 106.949, $\eta^2 = 0.588$, $p<0.001$], and Group × PA type interaction [F= 27.064, $\eta^2 = 0.265$, $p<0.001$]. The post-hoc analysis revealed that the VMC was higher during working hours with respect to leisure-time for both registered nurses (~$191x10^3$ vs ~$144x10^3$, $p<0.001$) and certified nursing assistants (~$296x10^3$ vs ~$153x10^3$, $p<0.001$). Moreover, during working hours, certified nursing assistants exhibited significantly higher VMC than registered nurses ($p < 0.001$), whereas no significant difference was observed between the two groups during leisure-time ($p = 0.458$) (see Figure 1).

Additionally, the hourly patterns of overall PA, expressed in terms of VMC, for both groups are reported as supplementary materials (see Appendix Figure A.1, http://links.lww.com/JOM/C161).

2.4. *Percentage of time spent at different levels of physical activity*

After controlling for the age effect, statistical analysis found a significant main effect of both Group [F(4,72)= 20.896, Wilks'λ=0.463, $\eta^2 = 0.537$, $p<0.001$], PA type [F(4,72)= 41.675, Wilks'λ=0.302, $\eta^2 = 0.698$, $p<0.001$], and Group × PA type interaction [F(4,72)= 13.917, Wilks'λ=0.564, $\eta^2 = 0.436$, $p<0.001$]. The post-hoc comparison revealed that registered nurses and certified nursing assistants have quite similar PA level composition during leisure-time (p=0.458), whereas during working hours, certified nursing assistants perform significantly higher levels of

moderate and vigorous PA (see Figure 2 and Table 2).

2.5. Number of steps traveled and weekly minutes of sedentary behavior and physical activity intensities

The statistical analysis found a significant main effect of both Group [F= 25.938, $\eta^2 = 0.257$, $p<0.001$], PA type [F= 121.471, $\eta^2 = 0.618$, $p<0.001$], and Group × PA type interaction [F= 23.435, $\eta^2 = 0.238$, $p<0.001$]. The post-hoc comparison revealed that the number of steps travelled per hour was higher during working hours with respect to leisure-time for both registered nurses (1053 vs 784, $p<0.001$) and certified nursing assistants (1548 vs 819, $p<0.001$). Moreover, during working hours, certified nursing assistants performed a significantly higher number of steps than registered nurses ($p < 0.001$), whereas no significant difference was observed between the two groups during leisure-time ($p = 0.458$) (see Figure 3).

Descriptive statistics for weekly minutes of SB, LPA, MPA and VPA intensity are presented in Figure 4, both in aggregate and stratified by working hours and leisure-time forms.

2.6. Relation between leisure-time and occupational physical activity

Considering the overall PA defined in terms of VMC, the analysis revealed a statistically significant correlation between registered nurses' VMC values during working hours and leisure-time VMC ($r = 0.768$, $p<0.001$), but not for certified nursing assistants ($r = -0.194$, $p=0.427$) (see Figure 5). Furthermore, the correlation analysis between the percentage of time spent at different PA levels revealed several significant relationships for both registered nurses and certified nursing assistants (see Tables 3-4).

3. Discussion

The present study aimed to provide a quantitative assessment – by means of unobtrusive wrist-worn accelerometers – of the PA and SB performed by nurses employed in different roles, investigating differences and potential relationships between OPA and LTPA patterns. The main findings can be summarized as follows: certified nursing assistants exhibited higher activity levels during work compared with registered nurses, whereas levels of LTPA were comparable between the two groups. These results will be discussed in the following paragraphs in relation to previous research, with specific consideration of the balance between OPA and LTPA, as well as current WHO recommendations.

3.1. Occupational and leisure-time physical activity levels in nursing populations

Our findings revealed that certified nursing assistants exhibited substantially higher OPA than registered nurses, as indicated by a 35% higher VMC. This difference was primarily explained by their time distribution across PA intensity levels: certified nursing assistants spent less time in SB (29% vs. 53%) and more time in MPA (20% vs. 8.8%) and VPA (20.5% vs. 9.1%), while LPA was similar between groups (~30%). Similar figures have been reported by Jirathananuwat and Pongpirul [38] which found that nurse practitioners performed higher OPA than nurse managers. The proportion of SB among registered nurses closely mirrors previous accelerometer-based studies [2,26,32], yet is much higher than estimates from self-report methods[33], which tend to underestimate sedentary time[34-36]. Notably, the levels of MPA and VPA recorded among certified nursing assistants were markedly higher than those generally reported in the literature[3,26] . Such result can be explained by methodological differences in the PA measurements. Indeed Chappel et al.[37] reported that wearing accelerometers at the hip—as required by hospital guidelines which prohibit

the use of wrist-worn devices—tends to underestimate MPA and VPA compared with heart rate monitoring and visual observation. This underestimation likely occurs because a hip-worn accelerometer cannot adequately capture upper-body movements performed while standing during patient care. In addition, part of the observed differences may also be attributed to local healthcare practices, specific job characteristics, and occupational roles. For instance, Chappel et al[2,37], found that surgical nurses engaged in higher levels of PA than medical ward nurses. This may be explained by the fact that surgical ward nurses spend more time in direct patient care, as their patients often require more assistance and frequent assessments during the immediate post-operative period. However, information on differences between nursing roles is limited, as most previous studies have focused exclusively on registered nurses or have pooled different nursing roles together in the analysis (see the reviews by Chappel et al [2]; Janssen and Voelcker-Rehage [20]; Brennan and Green [38]).

When considering LTPA, the two groups showed very similar patterns, with about two-thirds of leisure time spent sedentary, 20% in LPA, and the remaining ~14% divided between MPA and VPA. These results are broadly consistent with prior accelerometer-based studies[25], although, they differ considerably from self-reported data[18], which often underestimate sedentary behavior and overestimate active behaviors.

3.2. Relationship between occupational and leisure-time physical activity

Our results showed no significant differences in patterns of PA performed during morning and evening shifts, and this is consistent with previous studies that identified time-of-day effects only when night shifts were included [2]. However, we found distinct relationships between OPA and

LTPA for registered nurses and certified nursing assistants. In fact, among registered nurses, leisure-time VPA was strongly and positively associated with occupational VPA, and negatively associated with SB and LPA at work, suggesting that individuals who are more active at work tend to engage in more intense activity during their leisure-time, thereby limiting SB, as similarly observed by Kruger et al.,[40].

In contrast, among certified nursing assistants, leisure-time MPA and VPA were positively correlated with occupational LPA, indicating a different behavioral pattern, in which higher low-intensity activity at work may co-occur with increased activity outside of work. Interestingly, no significant associations were found between occupational VPA and leisure-time PA of any intensity in this group, suggesting that their most intense physical effort is primarily limited to the occupational domain. This result aligns with Kaleta et al. [41], who found that workers expending over 4000 kcal/week in occupational PA were more likely to lead inactive leisure lifestyles. The contrasting relationships between OPA and LTPA found in this study can be interpreted through the "spillover versus compensation" framework proposed by Staines in the 1980s[42]. According to this perspective, physically active workers may either carry their activity habits into leisure time (spillover), as seen among registered nurses, or, alternatively, decrease LTPA to recuperate from strenuous job demands (compensation), as observed among certified nursing assistants.

3.3. Physical activity behavior, comparison with World Health Organization recommendations, and number of steps travelled

The 2020 adult guidelines on PA recommend a weekly volume of 150-300 minutes of MPA or 75-150 minutes of VPA or a combination of two [31]. Our results showed that both groups of nurses

met the recommended thresholds during leisure-time and working hours, consistent with findings from a systematic review [43] and a recent study by Brennan and Green[38]. However, while Chappel et al. [25] found that shift nurses accumulate more PA than the general population mainly due to high OPA, our results indicate that this is true only for certified nursing assistants, but not for registered nurses. These differences underscore the importance of considering the specific role of nurses participating in a study, as their varied responsibilities may yield distinct outcomes in terms of OPA.

The last parameter we considered in the characterization of PA performed by registered nurses and certified nursing assistants is the number of steps travelled. On average, our participants performed 1053 to 1548 steps/hour (for registered nurses and certified nursing assistants, respectively) during working hours, and approximately 800 steps/hour during leisure-time, irrespective of their role. Considering an 8-hour shift, these results are consistent with those reported by Wakui et al.[14] ranging between 14,913-17,842 steps, and Bellacov et al. [44] who reported 1704 steps/hour, in both cases for an 8-hour shift, but higher than those reported by Welton et al. (8,748 steps/shift)[15]. Differences in steps between groups may reflect role and seniority differences; for example, Chang and Cho [11] reported that nurses with less than one year of experience performed up to 40% more steps than more experienced colleagues, due to increased direct care duties and the need to fetch supplies.

3.4. Strengths and limitations

This study is one of the few [20] that quantitatively assessed OPA and LTPA in nurses, as most of the available data comes from secondary aims of studies or from those that consider OPA and

LTPA separately [2]. Moreover, none of the previous studies were carried out in Italy and focused explicitly on registered nurses and certified nursing assistants' care roles. These are essential factors to consider as, although there are global similarities in some nursing roles, the local context is important, as different countries will have different systems of nursing care, facilities, patient profiles, and resources that may impact on nurses' occupational physical activity levels.

Some limitations need to be acknowledged: firstly, nurses who participated in the present study were volunteers; therefore, a selection bias could have occurred, as the nurses who participated may have been those who perceive themselves as healthy and fit. Secondly, wearing the accelerometer on the wrist does not allow us to assess the type of activities (e.g., standing, walking, stair climbing, etc.); however, it increases wearing time compliance [45]. Finally, since our sample consisted predominantly of female nurses, we cannot rule out that part of the LTPA could be associated with unpaid work (e.g., housework, family care). Future studies should also consider these aspects.

3.5. Conclusions

This study provides novel, objective insights into the PA and SB patterns of nurses employed in different roles, highlighting significant differences between registered nurses and certified nursing assistants. Our findings emphasize the importance of considering specific nursing roles when assessing OPA, as job demands and responsibilities markedly influence activity levels. The positive association between OPA and LTPA in registered nurses suggests the adoption of active lifestyles beyond work, whereas certified nursing assistants' vigorous PA is predominantly job-related. The latter pattern may reflect a compensatory effect, whereby high levels of OPA increase

the need for recovery and limit engagement in LTPA.

This research contributes valuable data for the design of workplace interventions, highlighting the importance of targeting an optimal balance between PA and recovery (i.e., the Goldilocks principle[9]) and informs future studies on how occupational demands intersect with leisure behaviors in nursing populations. Future research should investigate the impact of non-work activities and long-term health outcomes to inform the development of comprehensive strategies that support nurse resilience and performance.

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5. Figures Legend

Figure 1: The histograms represent the vector magnitude counts values for registered nurses and certified nursing assistants, distinguishing between working hours and leisure time. The symbol * indicates a statistically significant difference (p<0.001).

Figure 2: Physical activity composition of working hours and leisure time in registered nurses and certified nursing assistants.

Figure 3: The histograms represent the number of steps travelled per hour by registered nurses and certified nursing assistants during working hours and leisure time. The symbol * indicates a statistically significant difference (p<0.001).

Figure 4: From top to bottom, the figure represents the daily hours spent in sedentary behavior and the weekly number of minutes spent in light, moderate and vigorous physical activity, overall and distinguishing between working hours and leisure time. Where available World Health Organization recommended thresholds are reported.

Figure 5: Pearson's correlation between occupational and leisure time vector magnitude counts, differentiating between registered nurses and certified nursing assistants

Figure 1

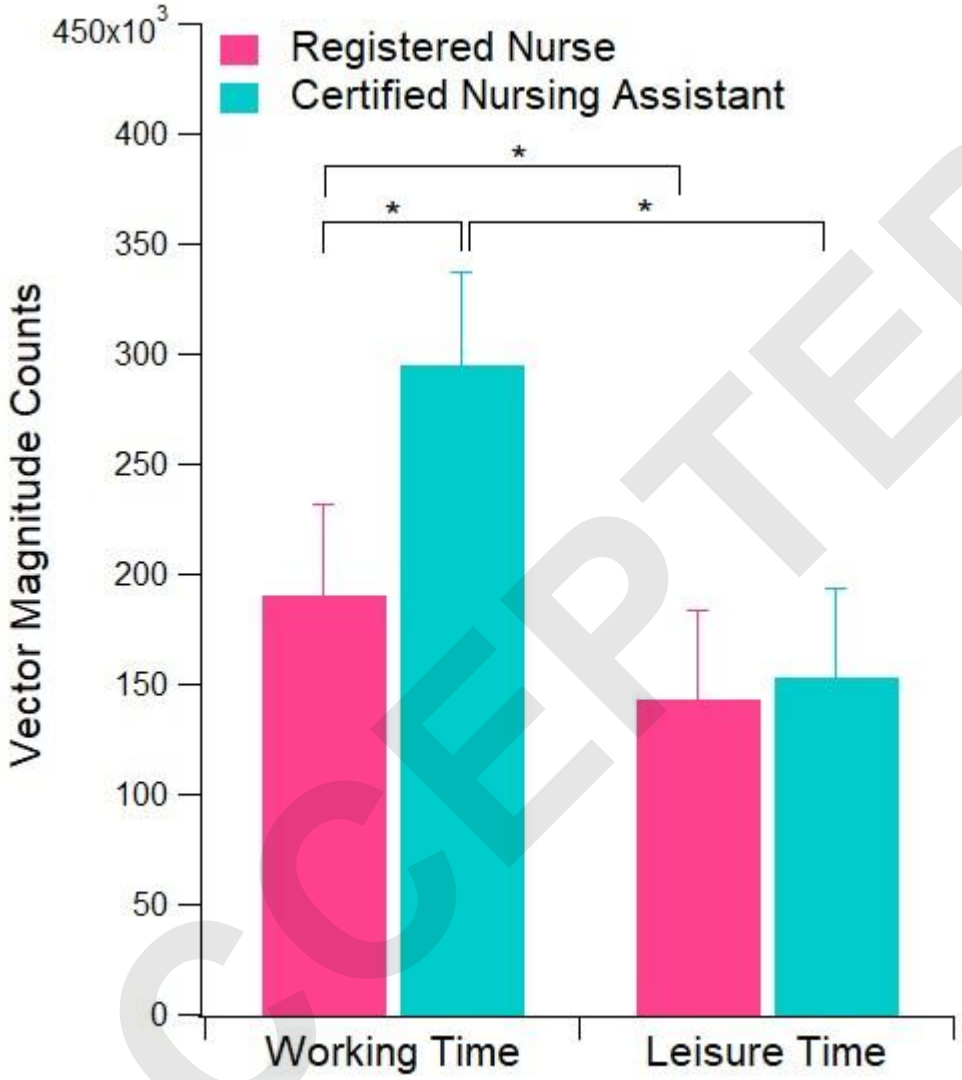

Figure 2

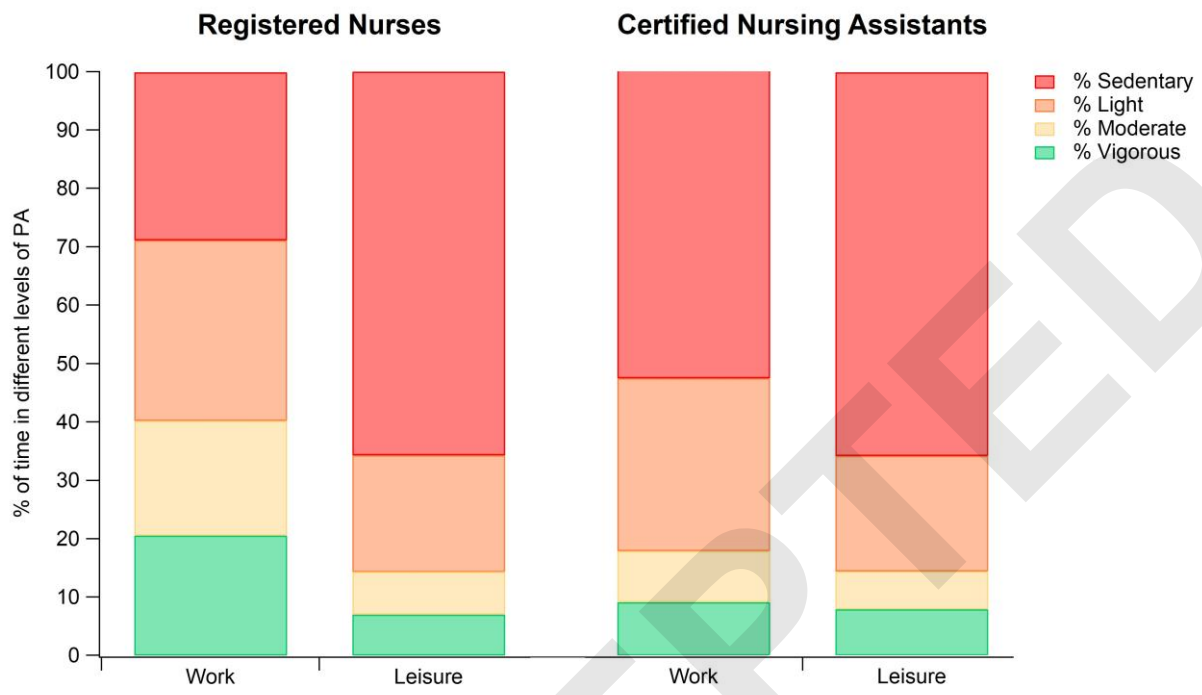

Figure 3

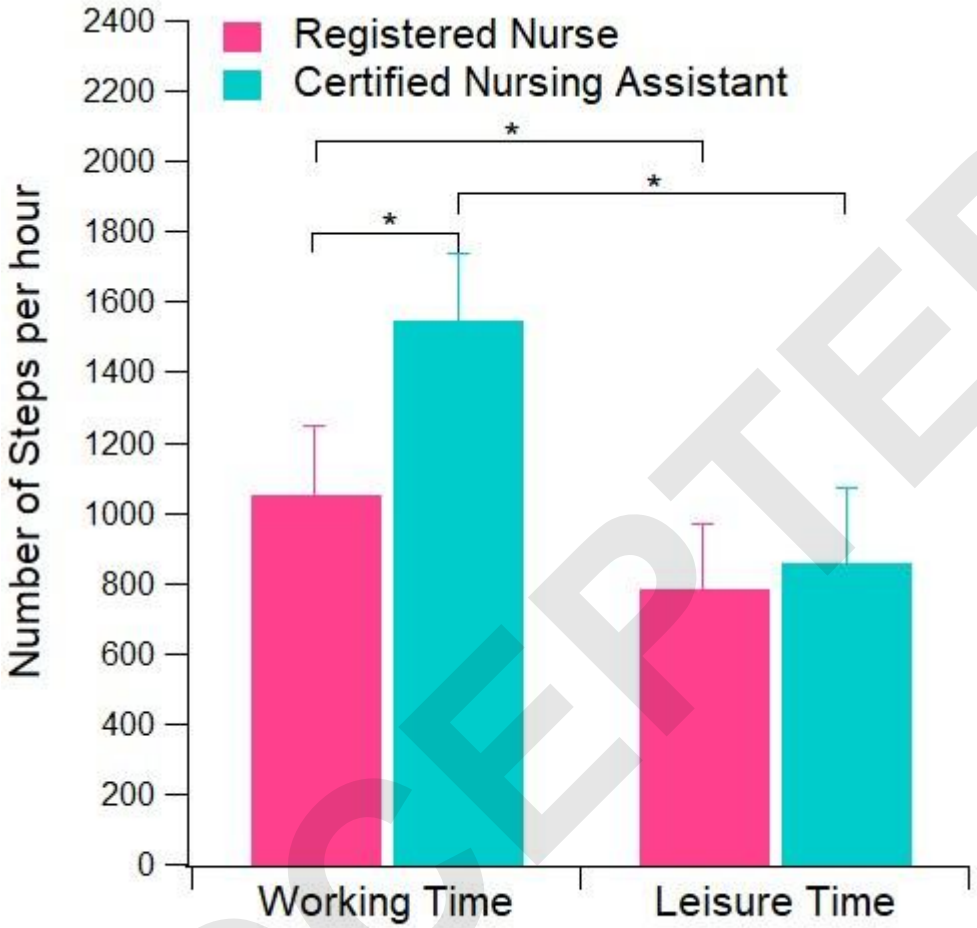

Figure 4A

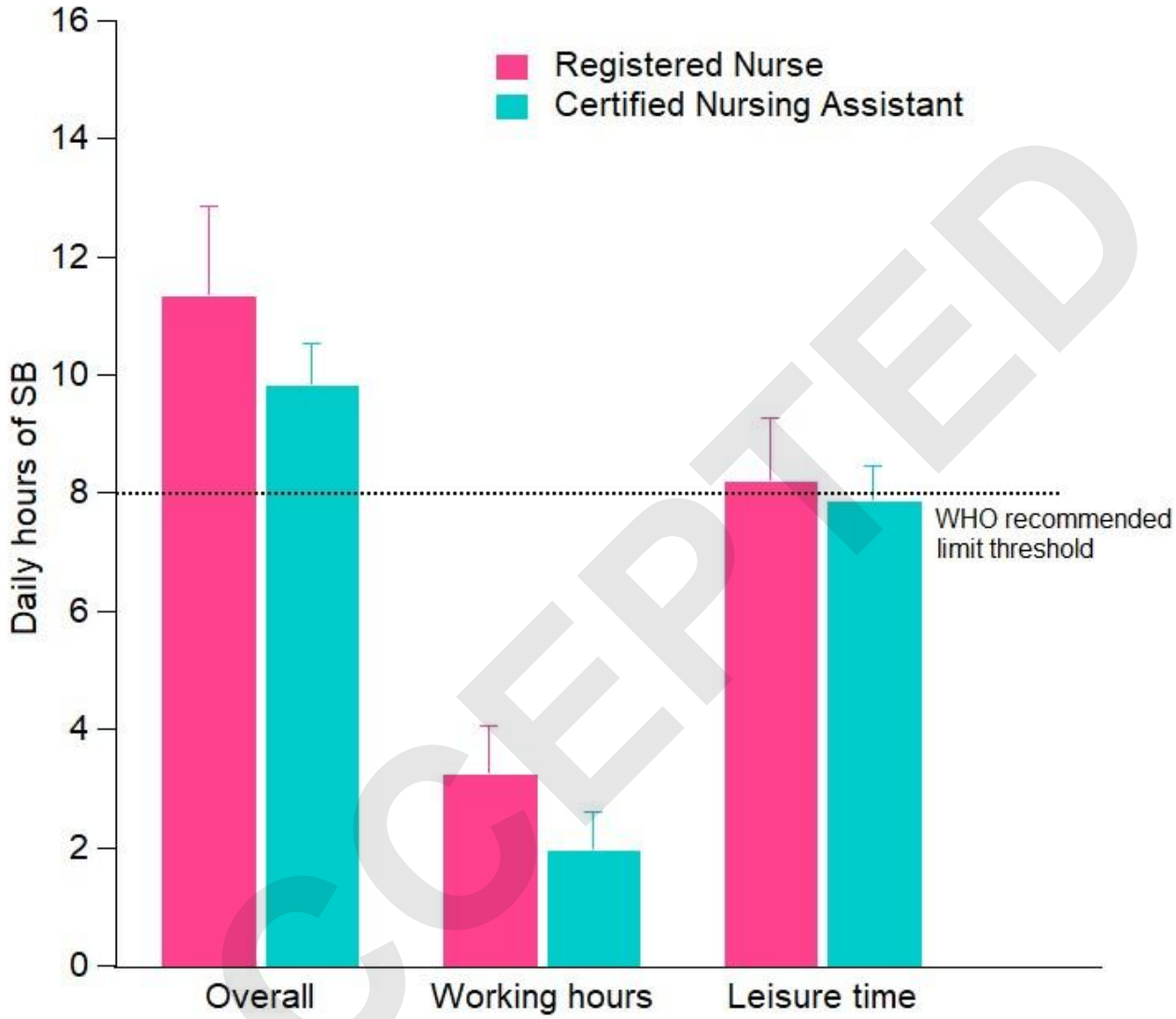

Figure 4B

Figure 4C

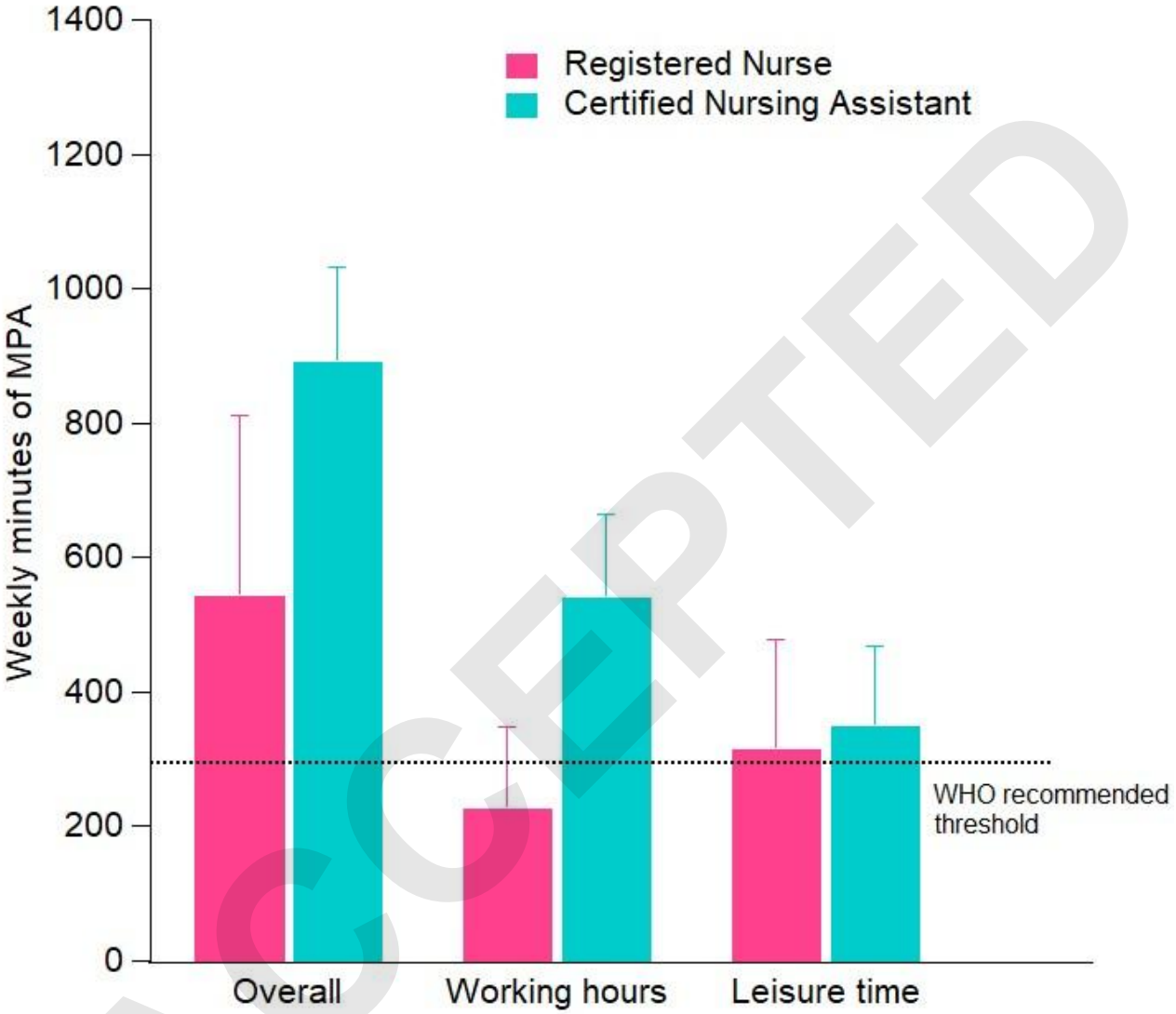

Figure 4D

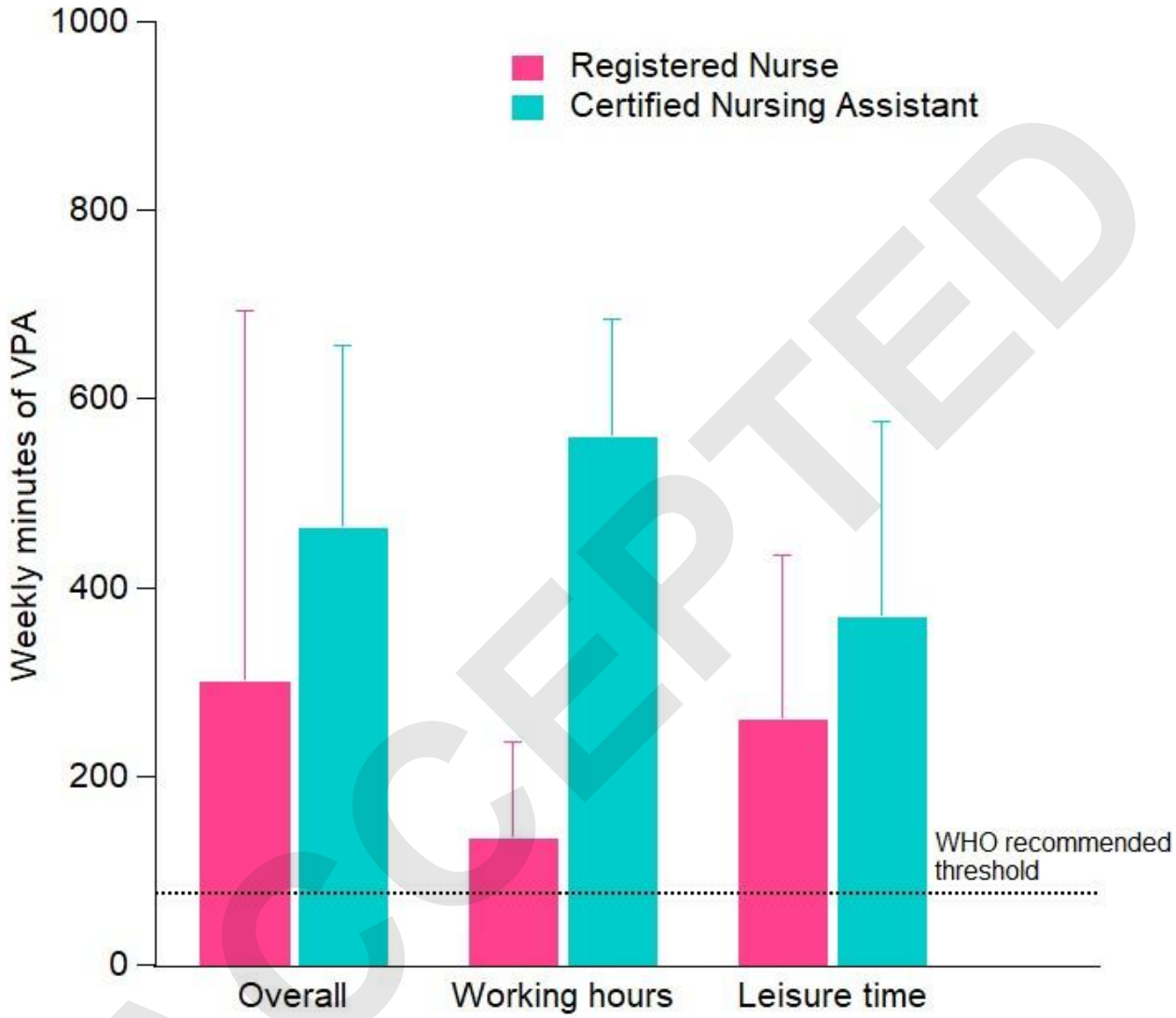

Figure 5

Table 1 Anthropometric and demographic characteristics of participants. Values are reported as mean (standard deviations, SD)

	Registered Nurses (*n*=12)		**Certified Nursing Assistants (*n*=10)**	
Sex	9 F, 3 M		8 F, 2 M	
	Mean (SD)	**Range**	**Mean (SD)**	**Range**
Age (years)	50.0 (5.9)	41.0 – 63.6	**47.6 (5.2)***	37.2 – 55.2
Height (cm)	165.8 (6.3)	155.0 – 178.0	164.6 (8.8)	151.0 – 183.0
Body mass (kg)	68.7 (10.8)	53.0 – 83.0	68.2 (17.3)	47.0 – 96.0
BMI (kg/m^2)	24.9 (2.9)	21.0 – 28.7	25.1 (5.8)	18.4 – 38.5
Work seniority (years)	28.7 (8.0)	11.0 – 37.0	**12.3 (5.2)***	5.0 – 20.0

The symbol * denotes a statistically significant difference vs. registered nurses as determined using an unpaired *t*-test ($p<0.05$)

Table 2: Percentage of time spent in different physical activity intensity levels during working hours and leisure time for registered nurses and certified nursing assistants. Values are expressed as mean (SD)

	Registered Nurses		Certified Nursing Assistants	
	Work	**Leisure**	**Work**	**Leisure**
Sedentary Behavior	**52.8 (9.9) [b]**	65.7 (8.4)	**28.9 (9.7)[a,b,c]**	65.7 (9.3)
Light Physical Activity	29.6 (7.2)	19.8 (6.0)	30.9 (6.3)	19.9 (4.9)
Moderate Physical Activity	**8.8 (6.5) [b]**	6.5 (3.2)	**19.7 (3.1) [a,b,c]**	7.3 (3.2)
Vigorous Physical Activity	9.1 (12.2)	7.9 (8.8)	**20.5 (6.5) [a,b,c]**	7.0 (4.1)

a,b,c, symbols indicate a statistically significant difference with respect to: a) registered nurses working time, b) registered nurses leisure time; c) certified nursing assistants leisure time

Table 3: Pearson's correlation between occupational and leisure time physical activity levels performed by registered nurses

		Occupational Physical Activity			
		SB	**LPA**	**MPA**	**VPA**
Leisure Time Physical Activity	**SB**	**0.572** **p = 0.007**	0.093 p = 0.688	-0.382 p = 0.087	-0.418 p = 0.059
	LPA	0.099 p = 0.670	**0.723** **p < 0.001**	0.297 p = 0.191	**-0.667** **p = 0.001**
	MPA	-0.346 p = 0.124	**0.447** **p = 0.042**	**0.725** **p < 0.001**	-0.268 p = 0.241
	VPA	**-0.506** **p = 0.019**	**-0.740** **p < 0.001**	-0.092 p = 0.691	**0.961** **p < 0.001**

Table 4: Pearson's correlation between occupational and leisure time physical activity levels performed by certified nursing assistant

		Occupational Physical Activity			
		SB	**LPA**	**MPA**	**VPA**
Leisure Time Physical Activity	**SB**	-0.405 p = 0.085	**0.676** **p = 0.001**	-0.122 p = 0.617	-0.011 p = 0.963
	LPA	0.197 p = 0.418	-0.318 p = 0.185	-0.017 p = 0.944	-0.024 p = 0.922
	MPA	**0.496** **p = 0.031**	**0.739** **p < 0.001**	0.165 p = 0.499	-0.052 p = 0.833
	VPA	0.373 p = 0.116	**0.701** **p = 0.001**	-0.134 p = 0.584	0.086 p = 727

Appendix

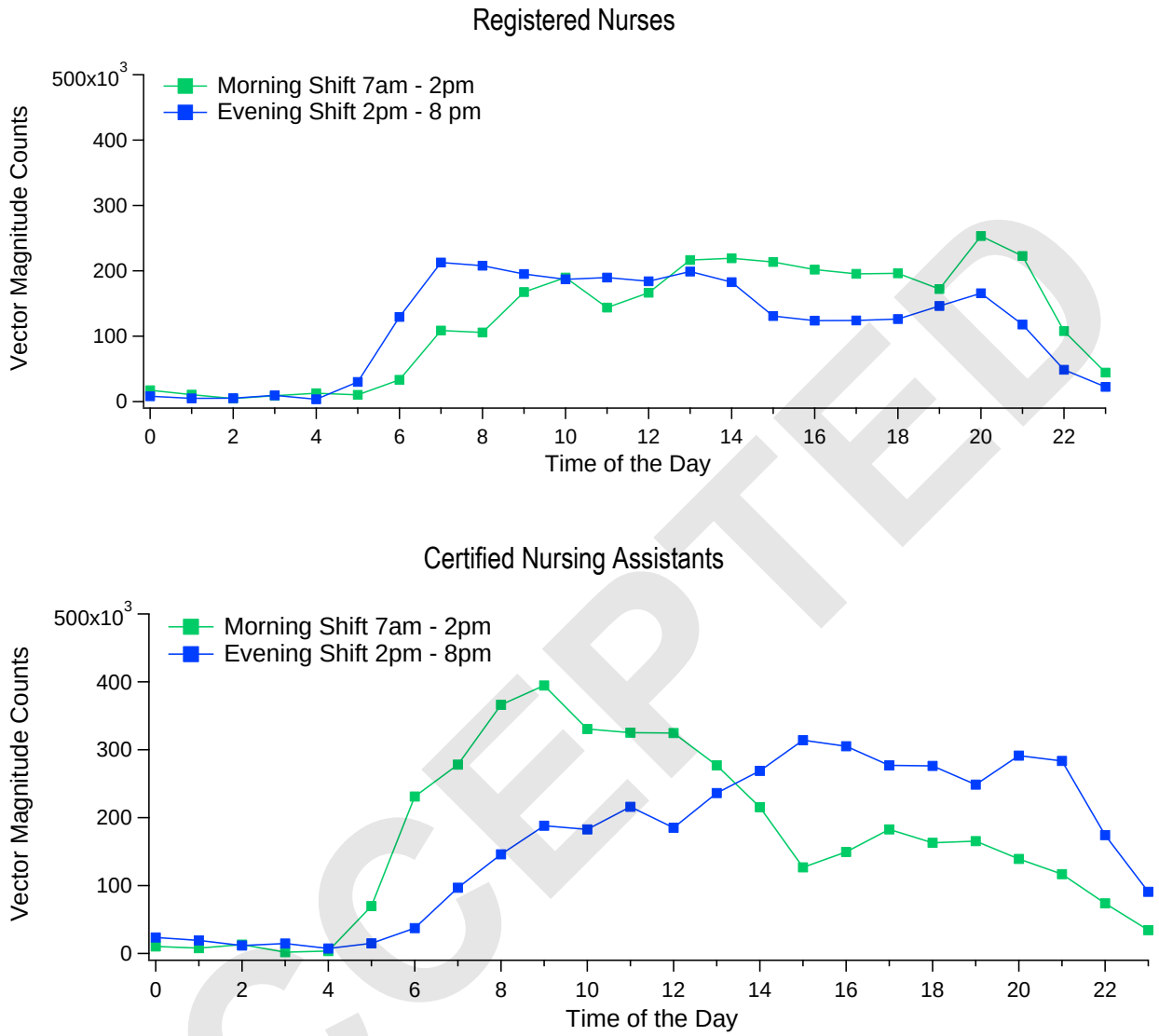

Figure A.1: Hourly pattern of overall physical activity in terms of vector magnitude counts for clinical nurses (top graph) and direct care nurses (bottom graph) distinguishing between morning and evening shift.

Visual Abstract