Motivation predicts change in nurses’ physical activity levels during a web-based worksite intervention: results from a randomized trial

Abstract

**Background:** Low physical activity levels can negatively affect nurses’ health. Given the low physical activity levels nurses report, the need for brief and economical interventions designed to increase physical activity in this population is clear. We developed a web-based intervention which utilized motivational strategies to increase nurses’ physical activity levels. The intervention provided nurses with feedback from an activity monitor coupled with a web-based individual, friend or team physical activity challenge. **Objective:** In this parallel-group randomized trial, we examined whether nurses’ motivation at baseline predicted changes in objectively-measured physical activity during the 6-week intervention. **Methods:** Participants were 76 nurses (97% female; mean age=46 years, SD=11) randomly assigned to one of three physical activity challenge conditions: 1) individual, 2) friend, or 3) team. Nurses completed a questionnaire online assessing motivational regulations for physical activity prior to the intervention and wore a Tractivity® activity monitor prior to and during the 6-week intervention. We analyzed data using multilevel modeling for repeated measures. **Results:** Nurses’ physical activity levels increased (linear estimate=10.30, SE=3.15), but the rate of change decreased over time (quadratic estimate=-2.06, SE=0.52). External and identified regulations, but not intrinsic and introjected regulations, predicted changes in nurses’ physical activity levels. **Conclusions:** Our findings provide evidence that an intervention incorporating self-monitoring and physical activity challenges can be effective in increasing nurses’ physical activity levels. Also, largely consistent with motivational theories and prior research, they suggest interventions incorporating strategies promoting motivation for physical activity should be developed and tested. **Trial**
Registration: This trial was not registered with clinicaltrials.gov like other trials conducted during the same enrollment period as registration was not required by the study sponsor.

Keywords: Physical activity, health professionals, motivation, randomized trial; wearable technology; web-based.
Introduction

A robust body of literature shows that engaging in regular physical activity can improve cardiovascular function and musculoskeletal strength, reduce the risk of morbidity and mortality due to chronic disease, and decrease the risk of mental health problems such as anxiety and depression [1-3]. The literature also demonstrates that engaging in physical activity can reduce work-related stress and the incidence of “burnout” [4-7] – a major problem for healthcare workers [8]. Many investigators have shown that nurses report high levels of work-related stress and burnout, low levels of job satisfaction, and poor health [9-13]. Despite the known benefits of physical activity, nurses’ activity levels remain low [14-17]. Common barriers to physical activity reported by nurses – who represent 48% of the healthcare workforce [18] – include busy schedules, irregular shifts, long hours, and a lack of time, suggesting that the worksite may be an ideal place to intervene to increase nurses’ physical activity levels [19]. Beyond personal health benefits, worksite interventions seeking to increase nurses’ physical activity hold the promise of improving employee performance, lowering employee healthcare costs, and decreasing absenteeism rates – which are higher among nurses than among other occupational groups [20]. The Internet is a promising way to deliver worksite interventions as it affords timely access and the ability to reach a large population [21]. It may be particularly appropriate for nurses whose long hours and irregular shifts preclude opportunities to participate in traditional face-to-face interventions that are generally scheduled to accommodate those with relatively fixed timetables. Several studies provide evidence that web-based interventions can help to increase physical activity levels among working-age adults [22-25]. There is evidence that web-based worksite interventions can be as effective as traditional methods (e.g., face-to-face, phone-based, print-
based materials) and are more effective than no intervention in increasing physical activity levels [see 26 for a review].

Nevertheless, some web-based worksite interventions have not led to significant increases in physical activity levels [e.g., 27, 28]. Speculating that it may be because participants lose interest over time, Zacharia et al. [26] suggested that future interventions include motivational features to maintain the desired behaviour. The effectiveness of web-based worksite interventions has been evaluated in different settings, with some studies targeting people who were required to sit as part of their job (e.g., desk workers in a variety of office settings) and others involving those who were active as part of their job (e.g., police officers, industrial workers, and hospital employees). Thus, it would seem that the nature of the worksite and work-styles can affect the success of web-based interventions, limiting the ability to draw general conclusions about the effectiveness of web-based worksite interventions.

Additionally, although it has been recognized that changes in behaviours associated with a particular intervention may be influenced by the personal characteristics of the participant, few web-based worksite interventions have sought to identify which characteristics, apart from sociodemographic factors, have an influence [e.g., 27, 29, 30-33]. Of those that have, theoretical constructs from the social cognitive theory [34] have been the focus of attention and discussion. Consequently, there is limited knowledge of the factors that may predict physical activity among those participating in web-based worksite interventions. An examination of additional theoretical constructs that might predict physical activity in web-based worksite interventions is critical to acquire an enhanced understanding of the forces that impel change. There is robust evidence that motivation is a strong predictor of participation in physical activity [35]; researchers might therefore consider drawing on motivational theories such as organismic integration theory [36,
to ascertain whether motivation predicts physical activity among those participating in web-based worksite interventions.

To address the aforementioned gaps in the literature, we developed a web-based worksite intervention for nurses working in a tertiary-care cardiovascular treatment centre. We created individual, friend, and team challenge groups in which nurses would track their physical activity levels using an accelerometer (i.e., Tractivity® activity monitor) and uploaded their activity data at times and frequencies of their choosing. Participants randomized to the friend and team challenge groups shared in de-identified format their physical activity levels with one other nurse (friend challenge group) or a team of nurses (team challenge group), which, it was presumed, might motivate them to be more active in order to make a positive impression on members of their group according to self-presentation perspectives [38, 39]. Using data collected as part of a trial evaluating changes in physical activity and the impact on cardiovascular risk factors among nurses participating in a web-based worksite intervention [40], we assessed if nurses’ motivation predicted changes in their objectively-measured daily physical activity levels.

In this study, we examined motivation utilizing organismic integration theory [36]. Deci and Ryan [36] proposed six core motivational ‘regulations’ that range from non-regulated to self-determined forms of motivation. Intrinsic motivation is the most self-determined type of motivation and occurs when a person pursues an activity for the inherent pleasure and enjoyment of the activity. Extrinsic motivation includes four regulations differing in their level of self-determination: integrated regulation (i.e., a person pursues an activity because it is fully integrated with their sense of self and congruent with their personal beliefs); identified regulation (i.e., a person pursues an activity that they deem personally valuable and important to attain a desired outcome); introjected regulation (i.e., a person pursues an activity to avoid feelings of
guilt and shame and/or protect feelings of worth and ego); and, external regulation (i.e., a person pursues an activity because of external demands [e.g., punishments, threats] and/or possible rewards). Finally, when a person has a relative absence of intrinsic or extrinsic motivation and lacks a reason to act, they are said to be amotivated [41].

We hypothesized, considering organismic integration theory [36, 37] and associated research [35, 42], that self-determined motivational regulations would positively predict initial levels of, and changes in, objectively-measured daily physical activity levels among the participants in our study. As previous research has shown inconsistent associations between non-self-determined motivational regulations and physical activity [35, 42], we further hypothesized that these regulations would be unrelated or negatively associated with initial levels of, and changes in, objectively-measured daily physical activity levels.

**Methods**

**Setting and Procedures**

Following ethics approval by the University of Ottawa Heart Institute Research Ethics Board (Protocol No. 20130429), nurses working at the University of Ottawa Heart Institute – a tertiary-care cardiovascular treatment centre – were recruited to participate in this parallel-group randomized trial. Of note, like other trials during the same enrollment period, this trial was not registered with clinicaltrials.gov as registration was not required by the study sponsor. Further details about the design of this study and procedures have been reported previously [40]. Briefly, recruitment took place between September and November 2013 via posters distributed throughout the University of Ottawa Heart Institute, word of mouth, and announcements during nursing meetings and morning rounds. Nurses interested in participating in the study contacted the research staff and were deemed eligible if they: 1) were a registered nurse; 2) were able to
walk unassisted; 3) were willing to wear a stretchable ankle band which contained a physical activity monitoring device (i.e., accelerometer) and had access to the Internet; and, 4) were able and willing to provide written, informed consent. Nurses who: 1) were pregnant or lactating; 2) were unable to read and understand English; 3) had medical contraindications to exercise; or, 4) were already using an activity monitor to track their physical activity levels were not eligible. Eligible participants attended a study enrollment session with study staff where they provided written informed consent and then received a Tractivity® monitor along with instructions on using it and instructions for logging onto and uploading data to their Tractivity® web account (see Multimedia Appendix 1), and instructed to wear it from waking to bedtime (except during water activities) throughout the baseline (1 week) and intervention phases (6 weeks). In addition, they were asked to complete self-report measures (e.g., sociodemographics, work-related characteristics, motivational regulations for physical activity), and had their resting blood pressure, heart rate, and anthropometric measurements (i.e., height, body mass, waist circumference, body fat percentage) taken by research staff who were blinded to participants’ group assignment. Participants were asked to adhere to the following prior to these assessments: 1) no eating or drinking for four hours; 2) no moderate-to-vigorous physical activity for 12 hours; 3) no alcohol consumption for 48 hours; 4) to void their bladder (within 30 minutes); 5) to refrain from consuming caffeine and diuretic use unless prescribed by a physician; and, 6) to postpone measurement if retaining water due to changes in the menstrual cycle. Further details regarding these assessments can be found in Reed et al. [40].

Participants

In total, 76 nurses contacted the research staff, met eligibility criteria, and consented to participate in this study (see Figure 1). Their mean age was 46.3 ± 10.9 years, mean body mass index was 27.5 ± 5.6 kg/m², and their mean resting blood pressure was 115 ± 12/ 75 ± 8 mmHg.
Most were female (97%), worked only day shifts (52.6%), and performed clinical duties (71.6%). Additional information describing participants’ demographics, anthropometrics, shift profiles, and nursing roles are presented in Table 1 in Reed et al. [40].

**Figure 1.** Consolidated Standards of Reporting Trials (CONSORT) flow diagram of nurses recruited and reasons for withdrawals.

- Assessed for eligibility \((n=76)\)
  - Excluded \((n=0)\)
  - Drop-outs \((n=1)\)
    - Damaged activity monitor \((n=1)\)
- Randomized \((n=75)\)
  - Allocated to Individual intervention \((n=25)\)
    - Received allocated intervention \((n=25)\)
  - Allocated to Friend intervention \((n=25)\)
    - Received allocated intervention \((n=25)\)
  - Allocated to Team intervention \((n=25)\)
    - Received allocated intervention \((n=25)\)
- Follow-Up
  - Lost to follow-up \((n=0)\)
    - Discontinued intervention \((n=2)\)
      - No longer interested \((n=1)\)
      - Became pregnant \((n=1)\)
  - Lost to follow-up \((n=0)\)
  - Lost to follow-up \((n=0)\)
    - Discontinued intervention \((n=1)\)
      - Time constraints \((n=1)\)
- Analysis
  - Analyzed \((n=23)\)
    - Excluded from analysis \((n=2)\)
  - Analyzed \((n=25)\)
    - Excluded from analysis \((n=0)\)
  - Analyzed \((n=24)\)
    - Excluded from analysis \((n=1)\)
Of the 76 nurses who provided consent, 75 were randomized to the individual, friend, or team physical activity challenge groups; one dropped out following the baseline assessment due to a damaged Tractivity® monitor (see Figure 1). Randomization to the three groups was conducted by research staff using the ‘RAND’ function of a software spreadsheet program (Excel, Microsoft, Washington, USA) using a 1:1:1 ratio; participants were notified of their group assignment via email. In the individual challenge group, participants were able to log onto their Tractivity® web account at any time during the intervention phase to track their physical activity (i.e., distance [km], steps [number], active time [minutes] and calories [kcal]) displayed in a graphical format in the online Tractivity® program. In the friend and team challenge groups, participants were also able to log onto their Tractivity® web account at any time during the intervention phase to track their own physical activity, but they could also monitor the physical activity of either one other participant (friend challenge group; see Multimedia Appendix 2) or four other participants (team challenge group; see Multimedia Appendix 3). Participants in the friend and team challenges groups were blinded in keeping with ethical considerations; none knew the identity of the other participant or team members in their group, respectively.

**Study Assessments**

Motivational regulations for physical activity were assessed at baseline using the 19-item Behavioural Regulation in Exercise Questionnaire-2 [BREQ-2; 43]. Participants were presented with the stem “Using the scale below, please indicate to what extent each of the following items is true for you” followed by items representing amotivation (4 items; e.g., “I can’t see why I should bother exercising”), external (4 items; e.g., “I feel under pressure from my friends/family to exercise”), introjected (3 items; e.g., “I feel ashamed when I miss an exercise session”), identified (4 items; e.g., “I value the benefits of exercise”), and intrinsic (4 items; e.g., “I
exercise being it’s fun”) regulations. Items were rated on a 5-point Likert scale ranging from 0 (not true for me) to 4 (very true for me). Integrated regulation is not assessed on this scale since it is difficult to differentiate between integrated and identified regulation [44]. We calculated subscale scores by averaging responses of items belonging to the same subscale; however, only the external, introjected, identified, and intrinsic regulation subscales were analyzed in this study due to the extremely low variance and high number of zeros for the amotivation subscale. The reliability and validity of BREQ-2 scores have been previously demonstrated [e.g., 45, 46].

Physical activity was measured regularly during the baseline (1 week) and intervention (6 weeks) phases using the Tractivity® activity monitor (Tractivity®, Vancouver, BC), which is a lightweight, compact accelerometer that uses a proprietary signal processing algorithm to determine step counts in one minute intervals. The activity monitor provides no visible feedback and stores up to 30 days of data (i.e., distance, steps, active time, calories). Research staff uploaded participants’ activity data into the online Tractivity® program at the end of the baseline and intervention phases. Participants uploaded their activity data at times and frequencies of their choosing throughout the intervention phase. The Tractivity® activity monitor has been shown to be a valid measure of step counts in comparison to direct observation [47]. Activity monitors were calibrated for stride length prior to the baseline week by having participants walk 10 steps (at their usual walking speed) in a straight line on a large indoor track. These measures were performed in triplicate, and the average was entered into the online Tractivity® program to assist the proprietary signal processing algorithm in calculating step counts.

The monitors provided us with consecutively ordered minute-by-minute activity data (i.e. steps, distance [km], active time [minutes] and calories [kcal]) during each day of the baseline and intervention phases for all participants. We used a Hypertext Preprocessor (PHP, version 7.0)
script to process the data. All activity monitor data were screened to identify valid and non-valid days. Data were considered valid and included in the analysis if wear time was at least 10 hours [48]. Step counts were used to calculate minutes of moderate-to-vigorous intensity physical activity in bouts of at least 10 minutes [49, 50]. Previously established cut-points [i.e., > 100 steps/minute; 51] were used to calculate daily minutes of moderate-to-vigorous physical activity.

**Sample Size**

A post-hoc power analysis revealed that a sample size of 76 participants provides adequate power (1–β = .92) to detect significant differences in physical activity within and between groups of small magnitude (i.e., eta-squared value of .022 with an alpha of .05).

**Statistical Analysis**

All data analyses were performed using SPSS (version 24; IBM Corp, Armonk, NY, USA), and p<.05 was considered statistically significant. Descriptive characteristics for the sample were summarized using means (± standard deviations [SD]) or frequencies. Data were analyzed using multilevel growth modeling because repeated observations were nested within participants who were nested within groups [52]. When analyzing longitudinal data, multilevel growth modeling also offers the following advantages: 1) equally-spaced time periods are not required, 2) the number of time points may vary across participants allowing for the use of data from all participants to provide unbiased estimates of the outcomes, assuming data are missing at random, and 3) missing data are not problematic as long as they are missing at random [53]. Prior to these analyses, a two-step approach for transforming continuous, non-normalized variables to normal was applied to the moderate-to-vigorous physical activity data [54]; preliminary data analysis revealed that moderate-to-vigorous physical activity levels were not normally distributed. We also plotted each participant’s individual trajectory of moderate-to-vigorous physical activity levels, as defined by baseline estimated levels (intercepts) and change
over time (slopes). In addition, we created a new variable ‘Time’ for which baseline was coded as ‘0’ to serve as the reference point, and subsequent time points were assigned the following values of 1, 2, 3, 4, 5, and 6. This coding accounts for any differences in time intervals between points and allowed for interpretation of the intercept as predicted moderate-to-vigorous physical activity levels at baseline.

Results

Of the 75 participants randomized, 72 (96%) completed all study assessments, including 23 (92%) assigned to the individual challenge, 25 (100%) assigned to the friend challenge, and 24 (96%) assigned to the team challenge. A one-way analysis of variance was performed to compare baseline moderate-to-vigorous physical activity levels between participants who dropped out and those who completed the 6-week intervention. Results revealed no significant differences in baseline moderate-to-vigorous physical activity levels. Visual inspection of the plotted trajectories using predicted normalized moderate-to-vigorous physical activity values (see Figure 2) suggested it may not be adequate to summarize the pattern of change over time with a linear trajectory, but rather a quadratic trajectory over time. Thus, we fit an unconditional linear growth model (Model 1) and compared it to an unconditional quadratic growth model (Model 2) to formally test the optimal functional form of growth. There were several indications that a quadratic growth model was the most appropriate for representing the individual growth trajectories of moderate-to-vigorous physical activity levels (see Table 1; Models 1 and 2). First, the Akaike Information Criterion and Bayesian Information Criterion values were smaller for the quadratic growth model. Second, the fixed quadratic effect and the variance components of the quadratic model were significant and of nontrivial magnitude. Third, after re-fitting the two
models with full-information maximum likelihood, a likelihood ratio test comparing the linear model to the quadratic model indicated that the former should be rejected in favour of the latter.

**Figure 2.** Plot illustrating the individual trajectories for moderate-to-vigorous intensity physical activity (MVPA) at baseline (week 0) and throughout the intervention phase (weeks 1 to 6). More negative slopes correspond to greater decreases in MVPA levels.
Table 1. Fixed effects and fit statistics for the multilevel growth models of moderate-to-vigorous intensity physical activity.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>44.43 (5.13)†</td>
<td>34.71 (4.63)†</td>
<td>30.49 (12.24)†</td>
<td>34.85 (4.45)†</td>
</tr>
<tr>
<td>Time</td>
<td>-1.96 (0.79)*</td>
<td>10.30 (3.15)**</td>
<td>15.04 (8.37)</td>
<td>10.26 (3.03)**</td>
</tr>
<tr>
<td>Time squared</td>
<td>-2.06 (0.52)†</td>
<td>-2.83 (1.38)*</td>
<td>-2.06 (0.50)†</td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td></td>
<td>2.14 (5.74)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group by time</td>
<td></td>
<td>-2.40 (3.92)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group by time squared</td>
<td></td>
<td>0.39 (0.65)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External regulation</td>
<td></td>
<td>-1.60 (7.11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introjected regulation</td>
<td></td>
<td>5.65 (4.82)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identified regulation</td>
<td></td>
<td>11.43 (7.75)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intrinsic regulation</td>
<td></td>
<td>1.51 (6.33)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External by time</td>
<td></td>
<td>11.55 (4.83)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introjected by time</td>
<td></td>
<td>-6.29 (3.27)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identified by time</td>
<td></td>
<td>11.38 (5.35)*</td>
<td></td>
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<tr>
<td>Intrinsic by time</td>
<td></td>
<td>-4.05 (4.37)</td>
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</tr>
<tr>
<td>External by time squared</td>
<td></td>
<td>-1.87 (0.80)*</td>
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<tr>
<td>Introjected by time squared</td>
<td></td>
<td>0.91 (0.54)</td>
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<td></td>
</tr>
<tr>
<td>Identified by time squared</td>
<td></td>
<td>-2.08 (0.89)*</td>
<td></td>
<td></td>
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<tr>
<td>Intrinsic by time squared</td>
<td></td>
<td>0.75 (0.73)</td>
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<tr>
<td><strong>Goodness of fit</strong></td>
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<tr>
<td>2 Restricted Log Likelihood</td>
<td>4,803.96</td>
<td>4,747.55</td>
<td>4,739.56</td>
<td>4,696.33</td>
</tr>
<tr>
<td>Akaike’s Information Criterion</td>
<td>4,811.96</td>
<td>4,761.55</td>
<td>4,753.56</td>
<td>4,710.33</td>
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<tr>
<td>Schwarz’s Bayesian Information Criterion</td>
<td>4,828.61</td>
<td>4,790.68</td>
<td>4,782.65</td>
<td>4,739.28</td>
</tr>
</tbody>
</table>

* p<.05. ** p<.01. † p<.001.

From the quadratic model (see Table 1, Model 2), the significant fixed effects reflect that the mean for moderate-to-vigorous physical activity at baseline was 34.40 (standard error [SE]=4.63) minutes and that levels changed significantly over time in a curvilinear fashion (linear estimate=10.30, SE=3.15; quadratic estimate=-2.06, SE=0.52). In addition, there were significant random effects for the intercepts (estimate=815.85, SE=258.40); the slopes for moderate-to-vigorous physical activity (linear estimate=269.39, SE=122.85, quadratic estimate=8.07, SE=3.47); and, the covariance between the intercepts and quadratic slopes (estimate=-50.86, SE=21.22), reflecting that there is meaningful individual variability in
moderate-to-vigorous physical activity levels at baseline, change in moderate-to-vigorous physical activity levels over time, and that, on average, participants engaging in more moderate-to-vigorous physical activity at baseline tended to have greater increases in moderate-to-vigorous physical activity initially followed by steeper decreases.

In order to account for participants being nested in three groups, we expanded the unconditional quadratic growth model by adding group, group by time, and group by time squared as predictors. There was no statistically significant main effect for group or interaction between time (and time square) and group (see Table 1, Model 3), indicating that there were no group differences in moderate-to-vigorous physical activity levels at baseline or in change over time. We calculated the intraclass correlation coefficient, $\rho$, to further assess dependence in the grouped data. As $\rho$ was <.05 [indicating that dependence related to group membership could be ignored; 55], we proceeded to test subsequent models without group, group by time, and group by time squared.

Finally, we attempted to explain the possible variations in participants’ moderate-to-vigorous physical activity levels at baseline and over time by adding motivational regulations as predictors to the unconditional quadratic growth model. To fit this conditional growth model, we added the main effects of each grand-mean centered motivational regulation along with their interaction with time (and time squared). The results of this model are presented in Table 1 (see Model 4). No significant effects (i.e., main or interaction) were observed for introjected regulation and intrinsic motivation. In contrast, examination of the fixed effects shows that there is a significant interaction between time (and time squared) and external regulation, as well as between time (and time squared) and identified regulation. These findings indicate that there are differences in the simple slopes of moderate-to-vigorous physical activity as a function of external and identified regulations. To better understand the nature of these relationships, we
probed both interactions by a test of simple slopes at specific values of external and identified regulations, namely at high (1 SD above the mean), medium (at the mean), and low (1 SD below the mean) levels of regulation [see 56, 57]. Probing showed that the simple slopes for moderate-to-vigorous physical activity were significant only at medium (estimate=-3.93, SE=1.58) and high (estimate=-5.70, SE=2.49) levels of external regulation, but not at low levels of external regulation (estimate=-2.16, SE=1.12). Similarly, probing showed that the simple slopes for moderate-to-vigorous physical activity were significant only at medium (estimate=-3.96, SE=1.57) and high (estimate=-6.76, SE=2.48) levels of identified regulation, but not at low levels of identified regulation (estimate=-1.16, SE=1.10).

**Discussion**

According to the World Health Organization, the workplace is an ideal setting to implement health promotion initiatives to reduce non-communicable diseases risk factors [58]. Although worksite interventions seeking to increase physical activity levels among healthcare workers (e.g., allied healthcare providers, administrative staff) have been developed and implemented, few have targeted nurses specifically. Only half of these interventions significantly increased physical activity levels [e.g., steps, daily minutes, energy expenditure; see 59]. Nurses differ from other hospital workers because they may work long shifts (i.e., 8- to 12-hour shifts), irregular hours (i.e., rotating day, evening or night shifts), and undertake physically demanding tasks [e.g., transfer patients between beds/chairs/wheelchairs, reposition patients, push or pull beds/chairs/wheelchairs, carry equipment; 60] – all of which can adversely affect their health.

The traditional mode of delivering worksite interventions is face-to-face, but worksite and job characteristics may hinder nurses’ ability to participate in such programs. Recognizing that nurses represent one of the largest groups of healthcare workers globally [i.e., 48% of the healthcare workforce; 18], that they report low physical activity levels [61] – a known risk
factors for the onset of non-communicable diseases [62], and that the web may offer a way to reach nurses, we developed and implemented a web-based worksite intervention for nurses working in a tertiary care cardiovascular treatment centre. Few studies have sought to identify factors that may help to promote changes in physical activity levels within the workplace setting; thus, the aim of the present study was to examine if motivation predicted changes in objectively-measured daily physical activity levels among participating nurses. Our principal finding is that some, namely external and identified regulations, but not all types of motivation, predicted changes in nurses’ physical activity levels.

Compared to nurses with low levels of external regulation at baseline, nurses with medium and high levels of external regulation at baseline tended to have greater increases in moderate-to-vigorous physical activity at the start of the intervention phase in the present study. Contrary to the belief that external incentives can decrease people’s motivation to participate in physical activity [e.g., 37, 63, 64], these findings suggest that external incentives (e.g., financial incentives, competition prizes, recognition from others), pressures, and sanctions may play a role in initially increasing physical activity levels. However, the effects of external incentives appear to only be beneficial in the short-term, as nurses’ physical activity levels were not maintained at the end of the intervention phase (see Figure 2). As previously observed by other researchers [e.g., 37, 63, 64], external incentives, pressures, and sanctions may undermine people’s self-determined motivation to participate in physical activity, which raises questions concerning the use of such strategies to help nurses maintain physical activity levels over time. More research is needed to understand if and when external incentives, pressures, and sanctions could be used to increase nurses’ physical activity levels. It is possible that they may help nurses who are not regularly active commence activity until they recognize and enjoy the intrinsic rewards that
accompany physical activity (e.g., healthy weight, better sleep, stress management, improved psychological health).

Motivation has been shown to have a positive influence on physical activity behaviour when pursuing an activity that is deemed personally valuable and in which it is important to attain a desired outcome [35]. In support of these findings, nurses in the present study possessing medium and high levels of identified regulation at baseline tended to have greater initial increases in moderate-to-vigorous physical activity. This suggests that it is necessary to help nurses recognize and enjoy the physical, psychological, and social benefits that accompany physical activity in order to help them increase their physical activity levels. However, this approach may not be sufficient long-term; the findings in the present study also showed that nurses with medium and high levels of identified regulation had greater decreases in physical activity at the end of the intervention phase.

There are several factors that may have interfered with motivated nurses’ ability to maintain physical activity over time. On a personal level, nurses have often identified barriers to physical activity such as high workloads, conflicting schedules, and physical and emotional stress in their workplace. These barriers may have interfered with the ability of nurses to maintain physical activity levels in the present study. It is also possible that, despite being motivated, nurses lacked confidence and skills to sustain high physical activity levels. Nurses may therefore benefit from interventions that seek to enhance physical activity confidence and skills by providing teaching, training, and/or counselling on goal setting, self-monitoring, and action planning [65-67]. Furthermore, providing coaching, social support from family, friends, and staff, feedback on progress, barrier identification/problem solving, using follow-up prompts, and health checks may help to reinforce long-term changes in physical activity.

In addition to the personal factors that may have hindered sustained physical activity change in this study, targeting the entire worksite environment as opposed to the nurses within it
might have increased the effectiveness of our intervention as occupational constraints may have further inhibited nurses’ ability to maintain physical activity levels. Speculatively, worksite characteristics such as management structure, leadership, culture, and support for physical activity within the workplace may have been insufficient for nurses in the present study to translate their intention into long-term physical activity changes. Accordingly, comprehensive interventions that target both personal (e.g., motivation, self-management) and macro-level factors (e.g., worksite environment) may be warranted. With regard to the latter, policy interventions (e.g., arranging physical activity breaks during work) or environmental changes (e.g., using physical activity prompts in common areas [e.g., break rooms, bathrooms, elevators/stairwells], forming lunchtime physical activity groups, promoting stairway signs, having indoor and outdoor walking routes) may help to promote sustained physical activity. Fostering social support in the workplace has been shown to be an effective way to increase physical activity [67, 68]. In the present study, participants were randomized into an individual, friend, or group challenge – however no significant differences in initial levels of or changes in physical activity were observed between the groups. As the identities of the friend or group members were not disclosed to participants, it is possible that an opportunity to foster social support was missed. Future interventions should consider permitting participants to know the identity of their fellow participants and facilitate social support and relatedness (rather than simply social comparison) among them.

Limitations

Although promising, the results of this study should be interpreted with caution. First, the present study was conducted at a single worksite – a tertiary care cardiovascular treatment centre. Whereas there are similarities in some nursing roles, the local context may impact nurses’ physical activity levels as a result of differing systems of nursing care, facilities, patient load, and resources. The generalizability of the current findings to nurses working in other healthcare
settings and systems merits further exploration. Motivational regulations were only assessed at baseline. Thus, it is not clear to what extent the intervention impacted nurses’ motivation over time and to what extent this related to changes in physical activity levels. For example, nurses’ motivation may have increased or waned when comparing their activity level to others or as they gained more experience and confidence exercising over the 6-week trial. There is a risk that the present findings reflect a selection bias as participants were self-selecting. It is possible that the nurses who participated in this study may only be those who felt that they were healthy and fit enough to engage in a physical activity intervention and valued such activity. The non-significant association between certain motivational regulations and changes in physical activity levels may be explained by the fact that participants in the present study had relatively low (or high) scores at baseline, which may have precluded the ability to detect significant associations due to the limited variability in scores. There was some attrition, though dropout was distributed evenly across the groups. Finally, the intervention was only 6 weeks long, which may not have permitted time to facilitate long-term physical activity change.

Implications for Future Research and Practice

Understanding how best to promote physical activity among nurses remains an important endeavour as their low physical activity levels mean they are at increased risk of chronic disease and consequently at higher risk of being absent from work. To allow for a better consideration of the potential impact of interventions on nurses’ physical activity levels, more nurse-only intervention studies drawing on theories from the fields of psychology, sociology, behavioural economics, and/or management are needed to identify personal, situational, environmental, structural, and lifestyle factors influencing participation and effectiveness. In addition, given that nurses’ working environment and job characteristics can have detrimental effects [60, 69-71], the extent to which nurses’ workload, responsibilities, and working hours (e.g., shift length, type of
shift worked) influence their ability to engage in physical activity and the effectiveness of physical activity interventions should be studied. Finally, as increases in physical activity were not maintained over the course of the intervention, further research is clearly warranted to determine how web-based worksite interventions for nurses can be improved to support long-term changes in physical activity. Based on previous research [31, 72-76], providing individually-tailored lifestyle advice, physical activity plans and targets, and programs providing information on the benefits of physical activity, giving out physical activity self-monitoring devices, holding interactive lectures, offering weekly aerobic exercise classes, having a nurse champion, and/or encouraging short exercise breaks at work should be considered. Further, integrating behaviour change techniques, implementing cognitive behavioural training, and manipulating the worksite may increase the effectiveness of the intervention [65, 77]. Thus, future research to assess the effectiveness of physical activity interventions should be: 1) tailored to nurses’ individual needs, 2) address macro-level changes (i.e., policy changes, environmental modifications); and, 3) designed, implemented, and evaluated based on theory.
Conclusion
Although the International Council of Nurses has called for nurses to make “a personal commitment to eat healthily, exercise appropriately, drink sensibly and avoid the use of tobacco” [78] and the growing expectation that nurses should embody those behaviours they wish to promote [79], most nurses report low physical activity levels [13, 80, 81]. Despite this, worksite interventions aimed at increasing physical activity levels among nurses are scarce. Moreover, little consideration has been given to factors that may predict changes in physical activity levels within an intervention. The principal conclusion of the present study is that external and identified regulations for physical activity predicted changes in objectively-measured physical activity levels. Accordingly, strategies to promote motivation for physical activity, external and integrated regulations in particular, should be part of larger strategies to promote physical activity in future interventions. Nevertheless, as initial increases were not maintained over time, the findings also highlight that changing nurses’ physical activity behaviour long-term is difficult and requires continued effort. Work-related circumstances (e.g., job strain, nurse shortages, workload, long hours, night or irregular shifts) may introduce barriers (e.g., fatigue, lack of time) for physical activity. It is necessary to continue to investigate both personal and occupational factors that could help nurses sustain physical activity level in the long-term. Key stakeholders should be involved in the development, implementation, and evaluation of future worksite physical activity interventions for nurses to ensure they are feasible, sustainable, and adaptable to specific workplace demands.

Acknowledgements
We thank all the nurses who participated in this study and the staff at the University of Ottawa Heart Institute for their support in the conduct of this study. This was investigator initiated research. Funding was provided by the University of Ottawa Heart Institute to purchase the
equipment required for this study. The last author is currently supported by a New Investigator Award in Clinical Rehabilitation by the Canadian Institutes of Health Research.

**Conflicts of Interest**
The authors declare that they have no known conflicts of interest.

**Abbreviations**
BREQ-2: Behavioural Regulation in Exercise Questionnaire-2
MVPA: moderate-to-vigorous physical activity
SD: standard deviation
SE: standard error
References


