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Evening regular activity breaks extend subsequent free-living sleep time in healthy adults: a randomised crossover trial

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ABSTRACT

Objective To determine if performing regular 3-min bouts of resistance exercise spread over 4 hours in an evening will impact subsequent sleep quantity and quality, sedentary time and physical activity compared with prolonged uninterrupted sitting.

Methods In this randomised crossover trial, participants each completed two 4-hour interventions commencing at approximately 17:00 hours: (1) prolonged sitting and (2) sitting interrupted with 3 min of bodyweight resistance exercise activity breaks every 30 min. On completion, participants returned to a free-living setting. This paper reports secondary outcomes relating to sleep quality and quantity, physical activity and sedentary time which were assessed using wrist-worn ActiGraph GT3+ accelerometers paired with a sleep and wear time diary.

Results A total of 28 participants (women, n=20), age 25.6±5.6 years, body mass index 29.5±6.7 kg/m^2 (mean±SD) provided data for this analysis. Compared with prolonged sitting, regular activity breaks increased mean sleep period time and time spent asleep by 29.3 min (95% CI: 1.3 to 57.2, p=0.040) and 27.7 min (95% CI: 2.3 to 52.4, p=0.033), respectively, on the night of the intervention. There was no significant effect on mean sleep efficiency (mean: 0.2%, 95% CI: −2.0 to 2.4, p=0.857), wake after sleep onset (1.0 min, 95% CI: −9.6 to 11.7, p=0.849) and number of awakenings (0.8, 95% CI: −1.8 to 3.3, p=0.550). Subsequent 24-hour and 48-hour physical activity patterns were not significantly different.

Conclusions Performing bodyweight resistance exercise activity breaks in the evening has the potential to improve sleep period and total sleep time and does not disrupt other aspects of sleep quality or subsequent 24-hour physical activity. Future research should explore the longer-term impact of evening activity breaks on sleep.

Trial registration number Australian New Zealand Clinical Trials Registry (ACTRN12621000250831).

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Evidence indicates that evening exercise sessions have no disruptive effects and, in some cases, positive impacts on elements of sleep quality, however, current recommendations discourage exercise prior to bedtime. The regular activity breaks protocol has been shown to improve postprandial metabolism, however, the impact on subsequent sleep is unknown.

WHAT THIS STUDY ADDS

⇒ Interrupting evening sedentary time with 3 min of light-intensity to moderate-intensity bodyweight resistance exercises every 30 min extends subsequent free-living time spent asleep by 27 min and has no disruptive effects on other elements of sleep and 24-hour physical activity patterns in healthy adults.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Sleep hygiene recommendations should be reviewed to better reflect the current pool of evidence. Regularly interrupting prolonged sitting with short bouts of activity breaks is a promising intervention that may improve cardiometabolic health through multiple mechanisms (postprandial metabolism and sleep).

INTRODUCTION

Insufficient sleep can adversely affect diet[1] and has been associated with an increased risk of cardiometabolic diseases including incident coronary heart disease[2–4] and type 2 diabetes.[3 4] Other components of sleep are also important; difficulty with initiating and maintaining sleep also increases the risk of type 2 diabetes,[5] and disrupted sleep has been associated with a greater risk of coronary heart disease[6] and other cardiometabolic risk factors such as elevated blood pressure and blood lipid levels.[7]

Although higher levels of daytime physical activity generally promote better sleep, current sleep hygiene recommendations discourage high-intensity exercise prior to bed because exercise-induced elevations in body temperature and heart rate can result in poorer sleep quality.[8] However, these recommendations do not appear widely supported by current evidence, with many

experimental studies reporting no significant negative effects of late-night exercise on sleep quality[9 10] and some reporting favourable effects.[11–13] It may also be important to consider if changing activity patterns in the evening impacts overall physical activity and 24-hour activity patterns with existing data limited to children.[14] To date, no study appears to have investigated the impact of breaking up sedentary time in the evening by performing short bouts of light-intensity to moderate-intensity resistance exercises on subsequent sleep and physical activity patterns.

The evening period is a prime time to target behaviours that influence cardiometabolic health. Adults accrue the longest periods of uninterrupted sitting[15–17] and consume almost half their daily energy intake during this time.[18] Insulin sensitivity is also diminished in the evening[19] and together, these factors promote elevated postprandial responses, which can be detrimental to cardiometabolic health over time.[20] This activity breaks protocol, which interrupts evening prolonged sitting with 3 min of simple resistance exercises every 30 min, has shown to positively affect postprandial metabolism.[21] However, how this protocol, which increases the amount of activity participants are doing in the hours immediately preceding bedtime, influences subsequent sleep is unknown.

Therefore, the aims of this study were to determine the effect of performing regular resistance exercise breaks compared with prolonged sitting in the evening over 4 hours in a laboratory setting on the secondary outcomes sleep quantity and quality (sleep period time, efficiency and wake after sleep onset), sedentary time and physical activity over the subsequent free-living 48 hours.

METHODS

Study design

This study was a randomised crossover trial. This manuscript focuses on secondary outcomes related to sleep quantity and quality and patterns of physical activity and sedentary time. The primary outcome has been published previously, see Gale *et al*.[21] For further details, see attached the study protocol in online supplemental file 1.

Participants

This study was conducted in Dunedin, New Zealand. Thirty participants aged 18–40 years were recruited by word of mouth. A sample size of 30 participants was estimated to provide 80% power (5% significance) to detect a difference of 0.4 SD in glucose total area under the curve (which was the primary outcome of this study). Eligible participants were: non-smokers, not taking medications or supplements known to impact glucose or triglyceride metabolism, able to speak and understand English, without intolerances or allergies to gluten or dairy (these components were present in the test meals) and those who self-reported habitual sedentary time of more than 5 hours (work) and 2 hours (evening) per day. Participants were asked to obtain medical clearance if their responses to the Physical Activity Readiness Questionnaire indicated that physical activity may not be appropriate (n=1). Participants from across the body mass index categories (minimum 18.5 kg/m^2, no upper limit) were recruited to ensure representation from all groups given the relationship between obesity and glycaemic control. All participants provided written informed consent.

Preliminary measures

Participants attended an introductory session at the University of Otago to confirm eligibility for enrolment. Blood pressure was measured using an automated sphygmomanometer (OMRON HEM-907; Omron Healthcare; Kyoto, Japan) and a correctly sized cuff. Participants were excluded if their systolic or diastolic blood pressure readings were greater than 130 mm Hg and 90 mm Hg, respectively. Standard height and weight were measured in duplicate following standard procedures. Experimental protocols were discussed, and participants watched a video that demonstrated the exercises. Participants practiced the required exercises under supervision from the study research assistant (Registered Dietitian) who was instructed on how to observe and correct technique by a member of the research team who has a degree in Exercise Science (MCP). On completion of primary measurements, participants were fitted with an ActiGraph GT3X+ (ActiGraph, Pensacola, Florida, USA) accelerometer to be worn continuously (24 hours per day) on their non-dominant wrist for seven consecutive days to capture habitual physical activity and sleep patterns. Participants were provided with a wear time diary to record non-wear time, what times they retired to bed, attempted to sleep and woke up. Participants were also asked to record any physical activity performed while not wearing the accelerometer (eg, swimming or contact sport) or to record activities known to be inaccurately identified by the accelerometer (eg, stationary cycling, certain resistance-based exercises or yoga).

Randomisation

Participants were randomised to complete the two experimental conditions in one of two possible orders (figure 1), stratified by weight status. The randomisation sequence was generated by MCP prior to recruitment using Stata (V.16; StataCorp, College Station, Texas, USA) and concealed electronically. The randomisation sequence was revealed and assigned on the afternoon prior to each participant beginning their first experimental condition. Participants were informed of their allocated sequence on arrival.

Pre-intervention standardisation protocols

To minimise diet-induced variability on experimental days, participants were provided with a standardised breakfast, morning tea, lunch and additional snacks to be consumed before 14:00 hours on each experimental day. A detailed summary of the standardised meal protocol

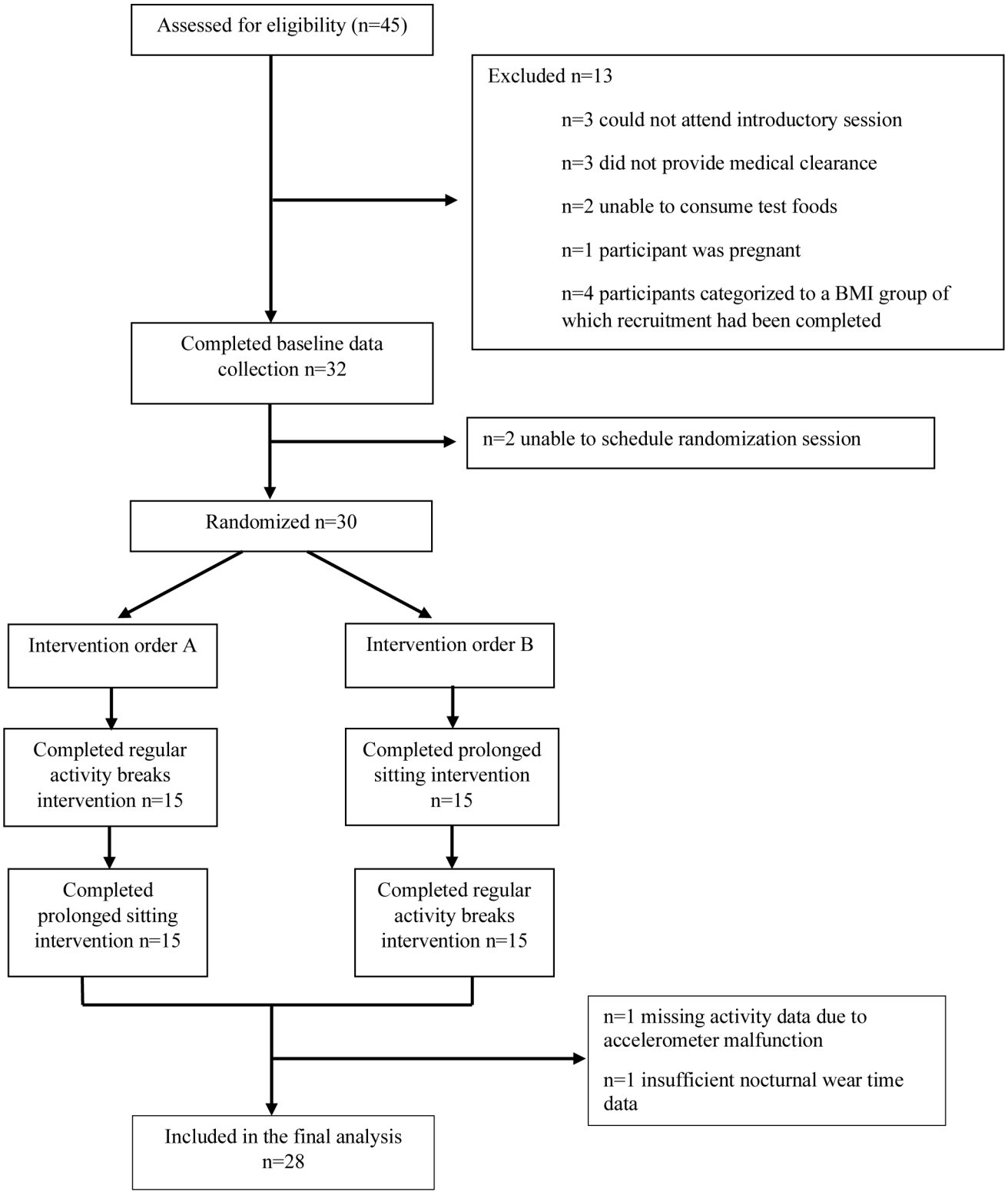

Figure 1 CONSORT study flow chart. BMI, body mass index; CONSORT, Consolidated Standards of Reporting Trials.

is reported elsewhere.[21] Participants were fitted with an ActiGraph GT3X+ accelerometer for continuous wear on their non-dominant wrist from the morning of the intervention day to 48 hours after the intervention. In the 24 hours prior to the first experimental condition, participants were asked to avoid all moderate-intensity to vigorous-intensity physical activity. Participants verbally self-reported compliance with all pre-intervention protocols before each experimental session.

Intervention protocol

Details of the laboratory intervention sessions have been described previously.[21] Each participant completed two 4-hour sessions, on the same day of the week,

from 17:00–17:30 to 21:30–22:00 hours, separated by a minimum 6-day washout to eliminate carry-over effects (median 6 days, IQR 6–12 days). The intervention sessions were conducted on either Tuesday or Thursday evenings, to ensure the next day was a 'typical' weekday, rather than a weekend day. In the prolonged sitting condition, participants remained seated for the duration of the session. The regular activity breaks condition was identical, except participants interrupted sitting with 3 min of simple resistance exercises every 30 min. Each break involved three exercises (chair squats, calf raises and standing knee raises with straight leg hip extensions) for 20 s each over three rounds. Participants performed exercises in time with a video recording of a person performing the exercises in a time standardised manner, and included reminders about form and a timer. These simple, body weight resistance exercises were chosen as the mode of activity breaks for this study as they do not require equipment, can be performed on the spot and have been used previously.[22] During the first session, participants were permitted to get up and use the bathroom as required and bathroom breaks were replicated during the subsequent session. While seated participants were able to watch television, read or work on a portable device during both conditions. Two standardised meals were provided during each condition at baseline and 2 hours. Sessions were supervised by two members of the research team. All participants completed every activity break, and no adverse events were reported during the breaks. Following the sessions, participants returned to their normal free-living environment with no further standardisation.

Physical activity and sleep data processing

For both periods of physical activity assessment (pre-trial habitual physical activity and the assessment of activity immediately prior to, during and after each intervention) time-stamped activity data were downloaded using ActiLife software (ActiLife V.6.13.4), saved in 15 s epoch and imported into Stata. Self-reported sleep and wake times were entered manually into ActiLife to constrain the Cole-Kripke algorithm[23] that determined sleep period time (time between self-reported time attempted sleep and the wake time), wake after sleep onset (WASO (minutes spent awake between sleep onset determined by algorithm and end of sleep)), total sleep time (amount of time spent sleeping during sleep period time for example, sleep period time minus WASO), number of awakenings and sleep efficiency (how consolidated the sleep was). The intensity and duration of activity performed during self-reported non-wear time (eg, contact sport) were identified and manually overwritten in Stata. Sedentary time was classified as <2860 counts/min, with total physical activity represented by over this cut point (ie, ≥2860), which therefore combines light, moderate and vigorous activity.[24] Valid wear time was classified as wear time ≥10 hours during waking hours.

Physical activity and sleep data were separated into two distinct time periods: intervention and post-intervention (online supplemental figure 1). The post-intervention period was defined as the 48-hour period following the end time of the experimental condition although each nocturnal period (defined based on self-reported attempted sleep and wake times) during the post-intervention period was analysed separately.

Statistical analysis

Thirty participants completed the study, however, two participants with missing data were excluded (n=1: accelerometer malfunction, n=1: removed accelerometer overnight). Twenty-eight participants were included in the analyses. To investigate differences between conditions, mixed-effects regression models were used with sleep and activity variables as outcomes, intervention condition as the independent variable and participant as a random effect. Mean differences, 95% CIs and p values were calculated. Residuals of models were plotted and visually assessed for homoskedasticity and normality. A p value of <0.05 was considered statistically significant. All

Table 1 Participant characteristics* (n=28)

	All
Age, years	25.6 (5.6)
Gender, n (%)	
Male	8 (29)
Female	20 (71)
Ethnicity, n (%)	
New Zealand European	21 (75)
Other	7 (25)
Anthropometric measures	
Weight, kg	84.6 (19.8)
Height, cm	169.5 (10.7)
BMI, kg/m^2	29.5 (6.7)
Weight status, n (%)	
Healthy weight	8 (28)
Overweight	10 (36)
Obese	10 (36)
Blood pressure, mm Hg	
Systolic	121.6 (8.6)
Diastolic	74.9 (9.0)
Activity, min/day	
Total physical activity	295.4 (79.5)
Sedentary behaviour	631.3 (86.5)
Sleep period time	467.3 (73.0)
Non-wear time	46.1 (43.5)

*Values reported as mean (SD), unless otherwise stated.
BMI, body mass index.

analyses were carried out in Stata V.17.0 (StataCorp LLC, College Station, Texas, USA).

Time spent in physical activity and sedentary behaviour were reported in (1) absolute minutes and (2) proportions of the waking day. Both are reported because if sleep period time is different between conditions, then absolute minutes in activity and sedentary time would necessarily be different due to the 24-hour constraint of the day. In this situation, the difference in activity or sedentary time may not represent the effect of the intervention directly, but rather represent displacement of other time because of a change in sleep period time. Proportions, however, describe differences in time-use composition of the waking day, independent of sleep period time. Both are informative.

The first 24 hours was analysed as the primary time period to assess the acute effects of regular activity breaks in the evening. The full post-intervention period (48 hours) was analysed as the secondary time period to determine if any acute effects were apparent over 2 days.

As an increase in these sleep and activity variables can be either health promoting (sleep period time, total sleep time, sleep efficiency and physical activity) or not health promoting (WASO, number of night awakenings and sedentary time), a forest plot was created so that direction and strength of effects could be visually assessed more easily. For this, all mean differences and 95% CIs were standardised to be in units of SD.

Equity, diversity and inclusion statement

Our research and author team consist of women, junior, mid-career and senior researchers from different disciplines (Human Nutrition & Dietetics, Biostatistics Sleep and Exercise Sciences); however, all members are based at one University. We acknowledge that our study population is mostly well-educated, white women. We did not purposefully recruit marginalised communities, nor did we investigate the effects of merorganisation on the observed responses.

RESULTS

This study was commenced in March 2021 and ended in October 2021 when the intended sample size was reached (n=30). Participants were mostly women, of New Zealand European ethnicity, and 19–39 years of age (table 1). Based on habitual accelerometry prior to intervention, participants spent 7 hours 47 min (SD 1 hour 13 min) asleep, 10 hours 31 min (1 hour 27 min) sedentary and 4 hours 55 min (1 hour 20 min) engaged in total (light and moderate-to-vigorous) physical activity on average. Three-quarters of participants had an optimal sleep duration, 21% were short sleepers (<7 hours) and 4% were long sleepers (>9 hours).

In the first nocturnal period, regular activity breaks increased sleep period time (the quantity of time between sleep onset and end of sleep) by 29.3 min (95% CI: 1.3 to 57.2, p=0.040, table 2) compared with prolonged sitting. There were no significant differences in sleep efficiency, WASO and number of awakenings. Total sleep time (amount of time a person spends sleeping during sleep period) was 27.7 min longer (95% CI: 2.3 to 52.4, p=0.033) following the regular activity breaks intervention (7 hours 12 min, SD 48 min) compared with prolonged sitting (6 hours and 45 min, SD 82 min) (table 2). Time that sleep was attempted did not significantly differ between conditions (11:56 pm for prolonged sitting and 11:58 pm for regular activity breaks) whereas mean wake times the following morning were different (7:35 am for prolonged sitting, 8:06 am for regular activity breaks (online supplemental table 1).

Table 2 The effect of regular activity breaks and prolonged sitting in the evening on sleep, physical activity and sedentary time in the following 24 hours (n=28)

	Prolonged sitting	Regular activity breaks	Mean difference* (95% CI)	P value
Sleep†				
Sleep period time, min	456 (87)	485 (49)	29 (1 to 57)	**0.040**
Sleep efficiency, %	89 (7)	89 (7)	0 (–2 to 2)	0.857
Wake after sleep onset, min	45 (30)	46 (32)	1 (–10 to 12)	0.849
Number of awakenings, n	17 (9)	17 (8)	1 (–2 to 3)	0.550
Total sleep time, min	405 (82)	432 (48)	27 (2 to 52)	**0.033**
Activity				
Total activity, min	299 (101)	281 (76)	–18 (–50 to 14)	0.265
Total activity as a percent of waking time, %	31 (10)	29 (8)	–2 (–5 to 1)	0.289
Sedentary time, min	646 (126)	641 (92)	–6 (–52 to 40)	0.806
Sedentary time as a percent of waking time, %	67 (10)	67 (8)	0 (–3 to 4)	0.933

*Mean difference, 95% CI and p values calculated using a mixed-effects regression model with participant as a random effect.
†Sleep n=27 as one participant removed accelerometer during sleep time.

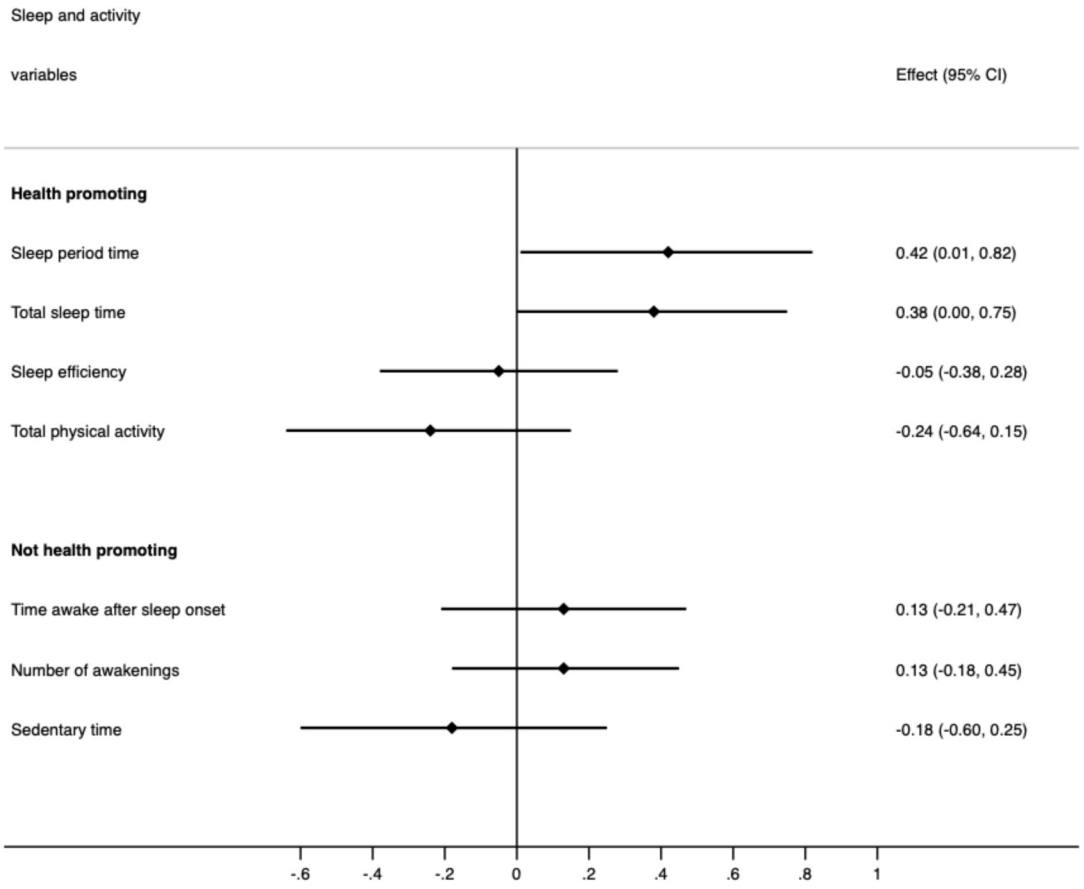

Figure 2 Standardised effect sizes for sleep and physical activity variables for night one following the regular activity breaks intervention compared with prolonged sitting, grouped as either health promoting or not health promoting.

There were no statistically significant differences in activity patterns in the 24 hours following each intervention. However, compared with prolonged sitting, the regular activity breaks intervention resulted in 18 min (95% CI: −50.3 to 13.8, p=0.265) less total physical activity and 1.6% (95% CI: −4.6 to 1.4, p=0.289) less waking time being active, in the 24-hour period following intervention.

Figure 2 shows health-promoting effects of regular activity breaks in the evening with increased sleep period time (effect size 0.42 SD, 95% CI: 0.01 to 0.82) and total sleep time (effect size 0.38 SD, 95% CI: 0.01 to 0.75), as well as a (small, non-significant) decrease in sedentary time. Decreases in sleep efficiency and total physical activity and increases in WASO and number of awakenings were all small (effect size <0.3) and non-significant.

There were no significant differences in measures of sleep or activity over the entire 48 hours following each intervention (table 3). The mean difference in sleep period time for regular activity breaks compared with prolonged sitting in the subsequent 48-hour period was 0 min (−20.5 to 20.5, p>0.999). Mean bedtime, sleep onset and wake times for each nocturnal period by intervention can be found in online supplemental eTable 1.

DISCUSSION

This study appears to be the first to explore the effect of evening resistance exercise breaks on subsequent sleep quality and physical activity patterns in healthy adults. Our results indicate that performing regular activity breaks in the evening in a laboratory setting significantly improves free-living sleep period time and total sleep time. Furthermore, this pattern of activity does not appear to disrupt other measured components of free-living sleep quality, nor does it negatively impact subsequent free-living physical activity.

These results add to a growing body of evidence that indicates evening exercise does not disrupt sleep quality, despite current sleep recommendations to the contrary. A meta-analysis of 23 experimental studies reported that, compared with no-exercise, performing one bout of physical activity ending within 4 hours prior to bedtime had no effect on total sleep time, WASO, sleep onset latency and efficiency.[10] Most of these studies used high-intensity cardiovascular physical activity protocols such as cycling or running, usually as a singular bout. Much less research has employed resistance exercise protocols[11 25 26] which may also be a more pragmatic and simple choice for evening activity breaks protocols as individuals can perform the breaks on the spot without interrupting evening activities, such a streaming, thus improving adherence. Our

Table 3 The effect of regular activity breaks and prolonged sitting in the evening on sleep, physical activity and sedentary time in the following 48 hours (n=28)

	Prolonged sitting	Regular activity breaks	Mean difference* (95% CI)	P value
Sleep†				
Sleep period time, min	478 (59)	478 (70)	0 (–20 to 20)	>0.999
Sleep efficiency, %	87 (6)	88 (6)	1 (–1 to 3)	0.236
Wake after sleep onset, min	54 (26)	52 (32)	–2 (–10 to 6)	0.638
Number of awakenings, n	19 (8)	19 (8)	0 (–2 to 2)	0.748
Total sleep time, min	416 (64)	420 (58)	5 (–13 to 23)	0.614
Activity‡				
Total activity, min	568 (183)	561 (166)	–8 (–58 to 42)	0.757
Total activity as a percent of waking time, %	30 (9)	28 (9)	–0 (–3 to 2)	0.727
Sedentary time, min	1274 (204)	1289 (208)	15 (–52 to 82)	0.661
Sedentary time as a percent of waking time, %	66 (10)	67 (9)	1 (–3 to 4)	0.761

*Mean difference, 95% CI and p values calculated using a mixed-effects regression model with participant as a random effect.
†Sleep n=25 as n=1 participant removed accelerometer during sleep time and n=2 participants did not have night two sleep data.
‡Activity n=26 as n=2 participants did not have sufficient wear time during day 2.

study extends these findings by showing that short bouts of resistance activity performed throughout the evening also do not disrupt sleep quality, and in fact may be beneficial to total sleep time.

While existing research indicates that evening exercise may not adversely impact sleep, the mechanisms by which evening exercise influences sleep quality remain unclear. Increases in core temperature and extended periods of heart rate elevation which can influence melatonin production and increase neurological activity are unlikely with regular activity breaks using resistance exercises[25 27] performed in short bouts, which may explain why there were no differences in sleep quality in the present study. However, the mechanisms behind sleep extension observed in the current study are harder to explain and require further mechanistic data to elucidate.

It is important to note that after completing the prolonged sitting intervention, more than half of our participants (57%) slept <7 hours that night. Therefore, regular bodyweight resistance exercise breaks in the evening have the potential to help individuals meet optimal sleep recommendations and, over the long term, reduce cardiometabolic disease risk. Furthermore, previous research indicates that 30 additional minutes of sleep time have been found to have a positive impact of clinical well-being, thus suggesting our results are clinically relevant, especially so if the benefit could be extended over the long-term.[28]

Over the subsequent two nocturnal periods, the mean difference in sleep period time between interventions was 0 min which could indicate some degree of compensation for the additional sleep accrued in the first nocturnal period. Interestingly, as studies often assess compensation for sleep loss rather than sleep extension,[29] explanations of this effect will require further research. Although not statistically significant, there was a reduction in total physical activity of 18 min in the 24 hours following the regular activity breaks intervention compared with prolonged sitting. However, as the proportion of waking time spent in total activity did not change, it seems likely that the additional sleep has, in this case, displaced some total activity.

Research and policy implications

These results provide further evidence that the prevailing guidance to avoid physical activity in the hours before sleep should be removed from sleep hygiene recommendations. To better assess compensatory effects, future studies should assess the impact of performing evening regular activity breaks on sleep quality and activity patterns over a longer period. Additionally, future research should investigate the mechanisms driving evening regular activity breaks induced sleep extension.

Strengths and limitations

Key strengths of the study include its crossover design, which controls for individual variability, and our examination of both the immediate effects of the exercise protocols on sleep and the longer-term examination on activity patterns. Rigorous standardisation protocols were employed for food and physical activity. These strengths elevate the likelihood that the increase in sleep observed can be attributed to the regular activity breaks. Word of mouth recruitment resulted in a sample that was mostly young adult women, which limits the generalisability of the findings. However, participants self-reported spending large parts of their day (at least 5 hours) and evening (at least 2 hours) sedentary. This probably reflects the activity patterns of a wider portion of the population as it is estimated that adults spend more than

half of the day engaged in sedentary behaviour.[30] There is limited nationally representative data on sedentary behaviour among New Zealand adults, however, habitual sedentary time of participants in the current study (65% of waking time) is slightly more than larger samples of adults from the USA (58% of monitored wake time).[31] Although participants were not screened for sleep disorders/complaints, objectively measured baseline sleep duration was somewhat similar to national data (collected via self-report) which indicated that ~68% of adults met sleep guidelines (75% in the current study) while 27% were short sleepers (21% in the current study).[32] As sleep was the main outcome, accelerometers were worn on the wrist, rather than on the waist (which is more appropriate for measurement of physical activity). As differentiating between moderate-to-vigorous and light-intensity physical activity can be difficult using existing wrist-worn accelerometry cut points,[33] only total physical activity was reported. As with all laboratory studies, the highly controlled setting may not reflect behaviour in a free-living setting. Thus, further research is required to assess whether activity breaks performed in the evening in a free-living setting can replicate beneficial impacts on sleep as reported here.

CONCLUSION

Evidence indicates that regular evening activity breaks have a positive effect on acute postprandial glucose and insulin responses in healthy adults.[21] The current study shows that this same protocol also extends subsequent sleep. Future research should explore the acceptability of performing regular evening activity breaks in a free-living setting to inform further intervention development. Additionally, future health initiatives could include tools (eg, a mobile application) to break up evening sedentary time with activity, which hold promise in improving cardiometabolic health via multiple targets (postprandial metabolism and sleep).

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Contributors MCP, JJH and RT contributed to conceptualisation. JJH and MCP contributed to methodology. JTG and JJH contributed to formal analysis. MCP, JJH and JTG contributed to investigation. MCP contributed to resources. JJH contributed to data curation. JTG contributed to writing—original draft preparation. JTG, DLW, JJH, RT and MCP contributed to writing—review and editing. JJH and MCP contributed to supervision. JTG contributed to project administration. MCP contributed to funding acquisition. All authors have read and agreed to the published version of the manuscript.

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Disclaimer MCP is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants. The study was approved by the University of Otago Ethics Committee (Health; H20/161, December 2020). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. Data described in the manuscript will be made available upon reasonable request to the corresponding author.

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