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Original research

Promoting physical activity in rural Australian adults using an online intervention

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ABSTRACT

Objectives: Rural Australian adults are consistently identified as insufficiently active, likely due to challenges implementing community-based physical activity programs in rural settings. On-line strategies to promote physical activity may be particularly effective in rural settings where isolation and scarcity of qualified support are potential barriers. The Rural Environments and Community Health (REACH) study evaluated the effectiveness of an online-delivered walking intervention among South Australian rural adults.
Design: Randomised controlled study design.
Methods: A twelve-week intervention, with six- and twelve-month follow-up, was conducted. Participants (n = 171; 50.6 ± 12.5 years), recruited through flyers, local newspapers and radio, were randomised to comparison or intervention groups and received a pedometer. The intervention group received access to the REACH website and personalised step goals based on ratings of perceived exertion and daily affect. The comparison group received a paper diary and generic step goals. Outcome measures were accelerometry-assessed sedentary, light (LPA) and moderate-to-vigorous (MVPA) physical activity. Linear mixed models assessed changes over the intervention and follow-ups.
Results: Sedentary time decreased, and LPA and MVPA increased in both groups across the intervention ($p < 0.05$). The intervention group demonstrated a larger increase in LPA at six-month follow-up relative to comparison ($p < 0.05$). Both groups decreased sedentary time, overall and in bouts ≥30 min, between baseline and twelve-month follow-up ($p < 0.05$). From baseline to twelve-month follow-up, MVPA (total min and bouts ≥10 min) declined more in the comparison group than the intervention group ($p < 0.05$).
Conclusion: While increased physical activity and decreased sedentary time were observed in both groups during the intervention period, maintenance was only observed for LPA at six-month follow-up in the intervention group. By twelve-month follow-up, post-intervention improvements had largely disappeared, suggesting that additional research is needed to identify ways to improve long-term adherence.

1. Introduction

There is compelling evidence that habitual physical activity reduces the risk of chronic conditions, including cardiovascular disease (CVD), stroke, type-2 diabetes, hypertension and some cancers.[1] More recently, independent contributions of prolonged sedentary behaviour to cardiometabolic health have been highlighted.[2] Yet interventions to promote physical activity and reduce sedentary behaviour remain largely unsuccessful.[3]

In Australia, 63% and 65% of rural men and women, respectively, are insufficiently active, compared to 55% and 60% in major cities.[4] This may be partly attributable to challenges implementing community-based physical activity promotion in rural regions that experience greater social isolation, lower access to services and physical activity opportunities, and environmental barriers such as extreme weather without shading and fresh drinking water, heavy vehicle traffic on major roads, low quality footpaths, inadequate street lighting in towns and larger distances to destinations such as shops and services.[5] With lower life expectancies and poorer

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health across a range of chronic conditions,[6] rural adults are a population for whom appropriately designed and implemented physical activity promotion is urgently needed, yet physical activity interventions targeting rural adults have thus far been unsuccessful.[7]

This study evaluated the effectiveness of the Rural Environments and Cardiovascular Health (REACH) study, an online-delivered walking intervention tailored for adults living in rural Australia. In line with systematic reviews on walking interventions[8] and internet interventions,[9] REACH was theoretically driven, drawing upon Social Cognitive (SCT),[10] Goal Setting (GST)[11] and Self-Determination[12] Theories. For example, in the context of activity interventions, SCT posits that targeting intrapersonal mediators (e.g. goal-setting, self-monitoring and self-efficacy), social mediators (e.g. family and peer support) and environmental mediators (e.g. access to facilities and opportunities) is more likely to elicit a positive and sustained response, with supporting evidence.[13] Further, GST was integrated with: (1) goal acceptance through education on the benefits of physical activity and lower sedentary time; (2) goal specificity through individualized step goals based on daily affect; (3) challenging goals through carefully managed positive increments in step targets; and (4) feedback through telephone conversations and graphical representation of progress on the website. Finally, with the freedom to choose which goal to aim for on a particular day (based on daily affect), the graphical representation of steps achieved, inclusion of blogs, information about local opportunities, weekly personal emails and regular telephone calls encompassing the spirit of motivational interviewing, the constructs of participant autonomy, competence and relatedness, central to SDT for developing autonomously regulated behaviour[12] were accommodated.

The current study reports changes in physical activity and sedentary behaviours in response to REACH. We hypothesised that the REACH intervention would be more effective at improving physical activity and sedentary behaviours, and maintaining improvements, compared to a 'standard' pedometer-mediated protocol.

2. Methods

The REACH trial adopted a randomised controlled design, comprising a twelve-week physical activity intervention, with assessments taken at baseline, post-testing (i.e. week 13), and six- and twelve-month follow-up (from start of intervention). The study was conducted between April 2013 and September 2014, with recruitment, baseline assessments and the intervention occurring between April and August 2013.

A detailed description of the study design, intervention protocol and outcome measures is published elsewhere.[14] The protocol was approved by the University of South Australia Human Research Ethics Committee and all participants provided informed written consent.

Recruitment involved strategically placed flyers in local businesses and other high pedestrian traffic community locations, as well as articles in the local newspapers and interviews on local radio, in three rural regions of South Australia: Riverland, Copper Coast and Lower Yorke Peninsula. These regions were selected as they are classified as predominantly 'outer regional' and the dominant employment sectors were indicative of those associated with rural Australia.

Eligible participants: were aged 18–70 years and a resident in one of the regions for at least twelve months; and had participated in fewer than 20 bouts of physical activity of $\geq$20 min in the preceding month according to self-report. Potential participants were screened for these eligibility criteria via telephone and completed pre-exercise assessments.

At all time-points, participants underwent seven days of physical activity monitoring and a series of health and anthropometric assessments.[14] Following baseline assessments, participants were randomised into the comparison or intervention group by clustered randomisation. This was done as participants often enquired about the study in small groups and maintaining these groups would reduce contamination and drop-out.

At baseline, separate information sessions were held for intervention and comparison participants, during which the importance of regular physical activity was emphasised and pedometers (Yamax DW700) were distributed for use during the intervention period. Comparison participants were issued a paper step diary to be filled out daily while intervention participants were shown how to use the REACH website. Intervention participants with limited home computer access were supported by local public facilities such as the library.

The REACH intervention comprised three key components: the REACH website, weekly personalised step goals and ongoing telephone support. The intervention group received access to the REACH website where they recorded daily steps, presented on a continually updated graph to provide feedback visually. Participants recorded their Rating of Perceived Exertion (RPE) during exercise using Borg's 6–20 RPE Scale[15] and their daily affective state (i.e. feelings of pleasure or displeasure) when they rose from bed each morning, using the Feelings Scale.[16] The 11-point bi-polar scale ranges from −5 to +5 with verbal anchors of feeling very bad (−5) through to very good (+5). Affective state has been shown to significantly influence exercise behaviour and motivation.[17]

The website enabled participants to share experiences with other intervention group members. A virtual notice board collated information on local community events and services, walking groups and other region-specific information. The website also provided access to healthy eating guidelines based on the current Australian nutritional guidelines.[18]

Supportive telephone calls (approximately 15 min), following the spirit of motivational interviewing, were provided to the intervention group in weeks two, four, seven and ten of the intervention. Phone calls were delivered by two research assistants trained for consistency of messaging and according to a set protocol. Conversations provided feedback on progress, website use, perceived barriers, injury/illness, correct interpretation of RPE and affect, and reinforcement of advice for increasing physical activity through incorporation into daily routines. Detailed notes were maintained so subsequent calls could address specific issues for each participant.

Personalised step goals were created for each upcoming week using the recorded steps, RPE and affect in the immediately previous and earlier weeks. Participants were encouraged to maintain RPE between 11 ('light') and 13 ('somewhat hard') while walking, a 'bandwidth' recommended for the less trained individual,[19] but one that would result in a positive affective response during exercise.[20] Step goals were provided at three affect levels that represented feeling 'good', 'OK' and 'bad' on any given day. The first week served as a baseline from which goals were set for week two. If participants did not meet their previous week's step goals on more than 50% of recorded days, the goals for the following week did not increase, and in some cases, were reduced. If a given week's goals were met on more than 50% of recorded days, a five per cent increase per week at each affect level was used to guide progression into the following week.

The comparison group was provided with generic daily step goals starting at 5000–6000 in week one, increasing 500 steps per week, towards 10,500–11,500 steps[21] in week twelve. One telephone contact was made in week two to ensure participants understood the requirements of the study and could use their pedometer to maintain their step diary.

Physical activity and sedentary behaviours were objectively assessed using triaxial, wrist-worn accelerometers (GENEActiv; Activinsights Ltd., UK). Data were collected for seven days at a sampling frequency of 100 Hz. Devices were worn on the non-dominant wrist, including during sleep and water-based activities.

Acceleration data were downloaded using GENEActiv PC software (version 2.2) and processed using custom Matlab software developed at the University of South Australia. Processing involved: calculating the vector magnitude of acceleration corrected for gravity (SVM; Eq. (1); calculating the sum of the SVM over 60 s epochs; removing sleep using self-report logs (corrected by visual inspection of acceleration trace where log information was missing or clearly erroneous); and activity classification using previously published cut-points[22] (sedentary <377, light <806, moderate <2263 and vigorous ≥2263 g.min adjusted for the sampling frequency).

Signal Vector Magnitude (SVM; gravity corrected)

$$= \sum |\sqrt{x^2 + y^2 + z^2} - g| \quad (1)$$

Valid days required at least 10 h of wear time during waking hours. Participants with a minimum of three week days and one weekend day were included in analyses. Overall, compliance with the activity monitoring protocol was excellent across each time point, with 93%, 87%, 89% and 82% of participants providing seven valid days, respectively, with no differences between groups.

Total time within each activity intensity was averaged over the monitoring period, providing the average time spent in sedentary, light physical activity (LPA) and moderate-to-vigorous physical activity (MVPA) per day, as well as the average SVM value as an indicator of overall activity.

Average daily sedentary and MVPA time spent in bouts of at least 30[23] and 10 mins, respectively, and the average number of sedentary and MVPA bouts per day, were calculated, to align outcomes with current physical activity recommendations.[24]

Descriptive statistics summarized baseline demographics and outcome measures, with between group comparisons made using independent t-tests or chi-square. Changes in outcome measures across the intervention were assessed using linear mixed models, with individuals added as random effects. The main effects of group and time were controlled for age and sex. To address the study hypothesis, a group × time interaction term was added to the models, with Cohen's d statistic calculated to explore differences in changes between groups when $p < 0.10$ for the interaction term. Analyses were performed using Stata (version 14; StataCorp LP, TX) with significance inferred if $p < 0.05$.

3. Results

One-hundred and seventy-one participants met eligibility requirements and participated in the intervention (Supplementary material 1). Baseline demographic characteristics did not differ between groups (Table 1). The sample was predominantly female (78%), full-time employed (54%), married (81%) and with an average BMI over 30 kg m^{-2}. Participants were sedentary for 10.1 h per day and engaged in 1.7 h per day of total MVPA. Forty-one participants (23 comparison, 18 intervention) were lost to follow-up, representing a 24% drop-out (Supplementary material 1). There were no differences in baseline characteristics between those who did and did not complete the study.

Table 1 also summarises the baseline sedentary and physical activity variables. Accelerometry data were unavailable for two, five, ten and four participants at time-points 1–4, respectively, due to technical difficulties or non-compliance with the monitoring protocol. There were no differences between groups at baseline for any of the sedentary or physical activity outcomes. Intervention participants logged on to the website a median of 43 times (IQR = 24–75, range = 2–301).

Table 1
Participant characteristics at baseline.

	Comparison (n = 86)	Intervention (n = 85)	p-value[a]
Men	14 (16.3)	23 (27.1)	0.087
Age (years)	49.5 ± 12.2	51.7 ± 12.8	0.254
BMI (kg m^{-2})	30.48 ± 5.47	31.50 ± 6.52	0.269
Education			0.677
Primary	0 (0.0)	1 (1.2)	
Secondary	38 (44.2)	37 (43.5)	
TAFE/Diploma	28 (32.6)	24 (28.2)	
University	20 (23.3)	23 (27.1)	
Employment status			0.082
Full-time	44 (51.2)	49 (57.7)	
Part-time	28 (32.6)	14 (16.5)	
Unemployed	2 (2.3)	3 (3.5)	
Retired	12 (14.0)	19 (22.4)	
Marital status			0.258
Married	74 (86.1)	65 (76.5)	
Previously married	8 (9.3)	12 (14.1)	
Never married	4 (4.7)	8 (9.4)	
Smoking status			0.135
Never	48 (55.8)	33 (38.8)	
Ex-smoker	29 (33.7)	37 (43.5)	
Occasional	2 (2.3)	5 (5.88)	
Daily	7 (8.14)	10 (11.8)	
Sedentary time (h)	10.15 ± 1.44	10.00 ± 1.37	0.497
Time in bouts[b] (h)	4.16 ± 1.76	4.07 ± 1.75	0.753
No. of bouts[b]	4.69 ± 1.61	4.60 ± 1.69	0.732
Light activity time (h)	3.75 ± 0.75	3.64 ± 0.91	0.408
MVPA time (h)	1.65 ± 0.83	1.70 ± 0.85	0.673
Time in bouts[c] (h)	0.73 ± 0.69	0.80 ± 0.66	0.487
No. of bouts[c]	2.22 ± 1.70	2.35 ± 1.62	0.611
SVM	337.28 ± 79.16	336.61 ± 82.59	0.957

Data presented as mean ± SD or n (%). BMI, body mass index; SVM, signal vector magnitude.
[a] Between group comparisons (t-test or chi-square).
[b] ≥30 min.
[c] ≥10 min.

Fig. 1 illustrates the changes in total sedentary and physical activity minutes over the intervention and follow-up periods. Considering descriptive changes in daily values, total sedentary minutes differed between baseline and post-intervention and baseline and twelve-month follow-up by −20.5 mins and −20.1 mins, respectively, in the intervention group. Differences of −5.4 mins between baseline and post-intervention and −9.0 mins between baseline and twelve-month follow-up were observed in the comparison group. For total daily MVPA, differences between baseline and post-intervention and baseline and twelve-month follow-up were +15.8 mins and +3.1 mins, respectively, in the intervention group. Differences of +9.7 mins between baseline and post-intervention and −7.6 mins between baseline and twelve-month follow-up were observed in the comparison group. After adjustment for age and sex in linear mixed modelling, sedentary time decreased and LPA, MVPA and SVM increased from baseline to post-intervention. This reduction in sedentary time was also observed at twelve-month follow-up and the increase in LPA at six-month follow-up. The decline in sedentary time from baseline to twelve months was not significantly different between groups. There were larger increases in LPA in the intervention group than the comparison group at six-month follow-up (Fig. 1B and Supplementary material 2). The Cohen's d for the between-group difference in change in LPA from baseline to six-month follow up was 0.36 (0.01–0.71, p (one tail) = 0.02).

For daily MVPA, between baseline and twelve-month follow-up there was a near significant group × time interaction ($p = 0.086$) suggesting more pronounced declines beyond the intervention period in the comparison than the intervention group (Fig. 1C and supplementary material 2). The Cohen's d for the between-group

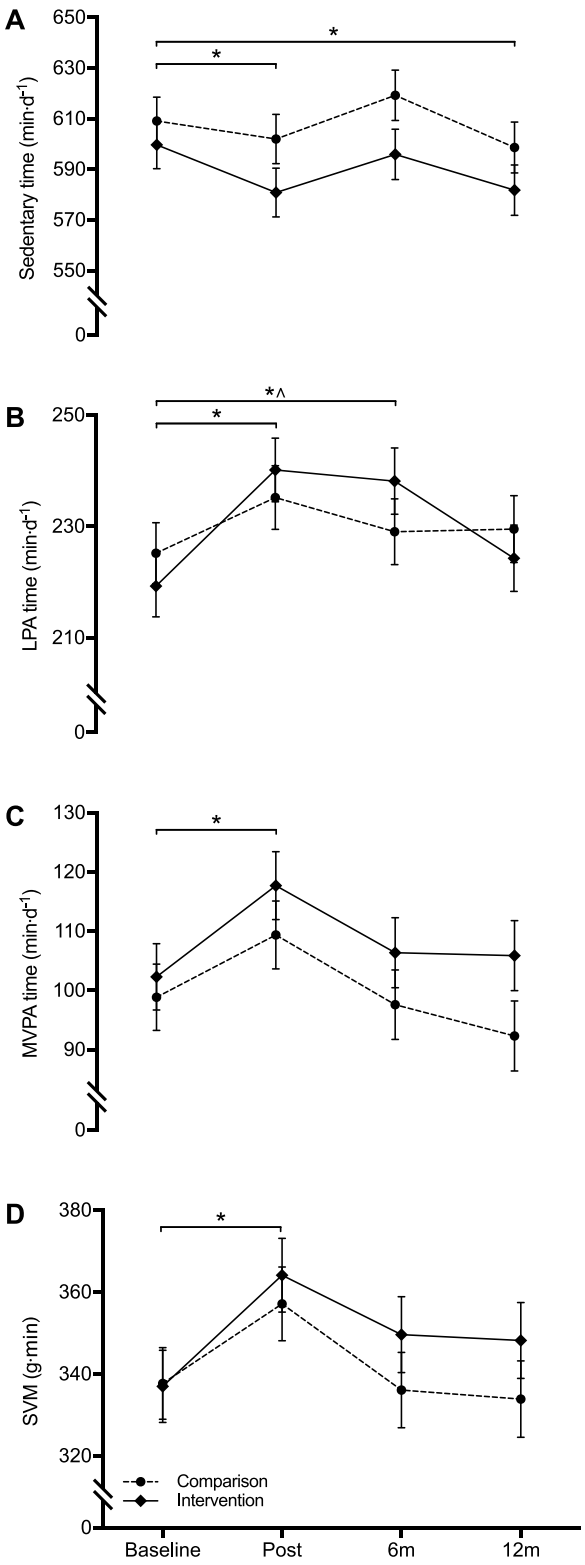

Fig. 1. Change in sedentary, LPA, MVPA and SVM across the intervention and follow-up periods.*Significant effect of time ($p < 0.05$), group × time interaction ($p < 0.05$).

difference in change in daily MVPA from baseline to 12 month follow up was 0.34 (−0.02 to 0.69, p (one tail) = 0.03).

Fig. 2 illustrates the changes in bouts of sedentary (≥30 min) and MVPA (≥10 min) by group. Considering descriptive changes in daily values, bouted sedentary minutes differed between baseline and post-intervention and baseline and twelve-month follow-up by −21.0 mins and −13.9 mins, respectively, in the intervention group. Differences of −12.6 mins between baseline and post-intervention and +1.4 mins between baseline and twelve-month follow-up were observed in the comparison group. For bouted daily MVPA, differences between baseline and post-intervention and baseline and twelve-month follow-up were +12.6 mins and +2.8 mins, respectively, in the intervention group. Differences of +5.9 mins between baseline and post-intervention and −7.8 mins between baseline and twelve-month follow-up were observed in the comparison group. After adjustment for age and sex in linear mixed modelling, time spent in bouts and the number of bouts were reduced for sedentary behaviour and increased for MVPA from baseline to post-intervention. The reduction in number of sedentary bouts was maintained at twelve-months in both groups. The group × time interaction for number and duration of MVPA bouts approached significance at the twelve-month follow-up ($p = 0.079$ and 0.083 respectively), suggesting a more pronounced decline in the comparison group than the intervention group (Fig. 2B,D). The Cohen's d for the between-group difference in change in MVPA bout number from baseline to 12 month follow up was 0.31 (−0.04 to 0.66, p (one tail) = 0.04). The Cohen's d for the between-group difference in change in MVPA bout duration was 0.33 (−0.02 to 0.68, p (one tail) = 0.03).

4. Discussion

Despite the obvious benefits of increasing physical activity to reduce the risk of chronic lifestyle related diseases, a recent meta-analysis of physical activity promotion among rural adults has demonstrated approaches to increase physical activity are largely ineffective.[7] Alarmingly, only four of the twelve studies included follow-up measures beyond the intervention, underscoring how little is currently known about effective physical activity behaviour change and maintenance of change in rural adults. In response to this gap, the current study tested the impact of a more nuanced and personalised goal setting intervention for behaviour change, along with the central role of choice and autonomy in the development of intrinsically driven motivation to maintain improved behaviours among rural Australians.

Whilst favourable changes occurred in all measured behaviours from the baseline to the end of the intervention, no differences were observed between groups. This is perhaps unsurprising as participants volunteered into the study and were therefore likely to be already motivated to change. Further, the comparison group received a standard intervention 'dose' comprising education on the benefits of physical activity, non-personalised incremental goal setting and a diary to log steps, a pedometer, and feedback by providing their health test results at each time point. However, in line with our hypothesis, the results demonstrated better maintenance of favourable behaviours beyond the intervention period among the intervention group, most notably for increased LPA at six-month follow-up. Declines in MVPA variables from baseline to 12-month follow up seemed more pronounced in the comparison group than the intervention group. The only difference in exposure between groups was engagement with the REACH website, which was primarily designed according to key elements of SCT and SDT. The results add to the growing evidence supporting autonomy and more self-determined sources of motivation for maintaining improved physical activity behaviours. A systematic review of 66 studies[25] concluded there is consistent support for a positive relationship between autonomous forms of regulation and exercise behaviour. Further, a recent web-based, pedometer intervention (based on SDT) with individualised goals in middle-aged inactive adults demonstrated efficacy for this model of intervention.[26]

Recent studies have shifted focus onto LPA and sedentary behaviour as targets for reducing CVD and metabolic syndrome

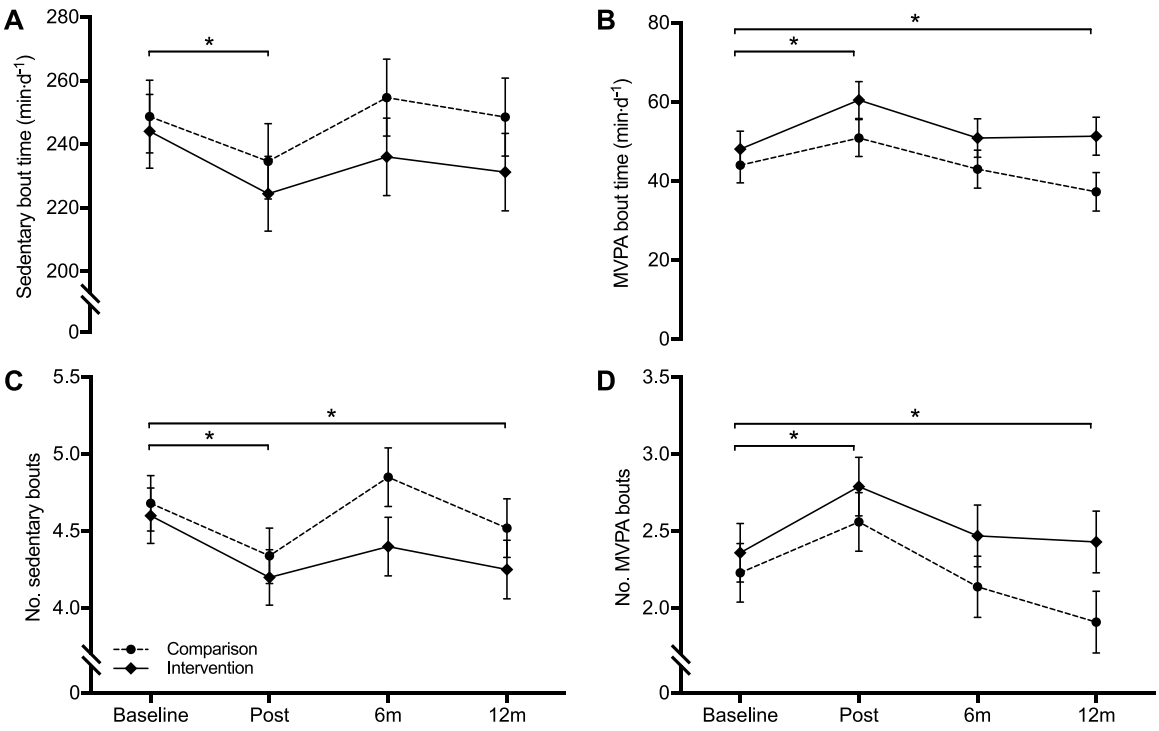

Fig. 2. Change in sedentary and MVPA bout time and number across the intervention and follow-up periods. Sedentary bout ≥30 min; MVPA bout ≥10 min.*Significant effect of time ($p < 0.05$).

(MetS).[27] Light-intensity physical activities such as walking for transport, leisure or occupational purposes, are the major source of variability in daily energy expenditure.[28] Together, these observations support targeting LPA in population-level health promotion. As sedentary time and LPA were highly inversely correlated in the current study ($r = -0.61$, $p < 0.0001$ at baseline), public health initiatives to replace sedentary time with LPA may be feasible and effective for minimizing negative influences of sedentary behaviours whilst increasing positive influences of LPA. Importantly, the results of the current study resonate strongly with the most recent Physical Activity and Sedentary Behaviour Guidelines for Australians 18–64 years,[24] that continue to emphasise the importance of regular MVPA but also highlight that 'doing any physical activity is better than none'.

Physical activity interventions often successfully induce behaviour changes across the duration of the intervention, but maintenance of these changes after the intervention period remains challenging.[29] Theoretically, the intervention in the current study contained processes to support participants developing more autonomous regulation, including individualised goals, choice of goals, graphical competence information from steps achieved, and supportive telephone interviews. However, the level of autonomous regulation was not directly assessed and it could be that participants had not progressed sufficiently along the continuum to more intrinsic regulation by the end of the intervention to maintain behaviour.[25] Indeed, although individualised, throughout the intervention the goals were set by the researchers and therefore could have been perceived as controlling and potentially undermining of self-determination. This suggests the need for REACH to be modified to shift responsibility of setting the daily goals to the participant over the intervention period and to introduce 'booster' strategies beyond the intervention period.

The use of an objective measures of physical activity and sedentary behaviour is a strength of the current study. Cleland et al.[7] recent meta-analysis indicated that intervention studies to promote physical activity among rural adults were more likely to demonstrate effects in favour of the intervention if the outcome variable was objectively measured rather than self-reported, perhaps due to differences in sensitivity to behaviour change.

Similar to previous physical activity interventions among rural adults,[7] relatively more females than males participated in the current study, and this would cloud any gender-specific responses to the intervention. A recent survey of Riverland adults[30] demonstrated 60% of males compared with 39% of females believed that they 'got enough physical activity at work' for their health, which may partly explain the lower recruitment of rural men into physical activity interventions.

At baseline, accelerometer measures showed approximately 45 min of MVPA accumulated in at least 10 min bouts, despite participants self-reporting low levels of physical activity over the preceding month. However, this is not unusual; self-report and accelerometer measures of physical activity have low to moderate correlations.[31] Self-report outcomes reflect perceived time-use and intensity of effort while accelerometry-based activity monitors derive outcomes from patterns of movement; these outcomes are not based on the same construct and therefore results from the two measures are not interchangeable.[32]

Accelerometer output was presented as time spent in different intensities of PA using published cut-points for sedentary, LPA and MVPA.[22] An independent cross-validation of these cut-points reported modest validity,[33] but it is well documented that PA outcomes can differ substantially depending on the choice of epoch length and cut-point.[34] As these cut-points were applied to both groups at repeated time points, this will not have impacted the outcomes of the study, but comparability to studies using different cut-points may be limited.

5. Conclusion

REACH is a computer-delivered strategy designed to address specific challenges to physical activity promotion in rural communities, namely social isolation and poor access to facilities

and expertise to guide behaviour change. The results of the trial indicated short term favourable changes in physical activity and sedentary behaviours in the intervention group and a comparison group that received a 'standard' walking intervention. Maintenance of behaviour change at six-month follow-up was observed in the intervention group in relation to LPA which has demonstrated associations with cardiometabolic health.[27] This suggests that engagement with personalised goal setting based on affect may be beneficial for adopting low intensity activity as a 'habit'. However, a tendency towards baseline values for most activity behaviours at twelve-month follow-up in both groups highlights the need for economically feasible, acceptable adaptations to the protocol that strengthen self-determination in the development of life-long engagement in regular physical activity.

Practical implications

- The use of an online delivered physical activity intervention may provide a cost-effective method for increasing physical activity behaviour in rural populations,
- A walking intervention that provides participants with personalised step goals based on the perception of effort and how participants are feeling may elicit a strong positive response, at least in the short term
- On-line interventions to increase regular walking in rural adults are likely to elicit sustained behavioural change if strategies to increase autonomous regulation are integrated.

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The authors acknowledge the results of this study are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jsams.2018.07.002.

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