Promoting physical activity in rural Australian adults using an online 1 intervention

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1 Abstract

2 **Objectives:** Rural Australian adults are continually identified as insufficiently active, likely due to
3 challenges implementing community-based physical activity programs in rural settings. The aim of
the

4 Rural Environments and Community Health (REACH) study was to evaluate the effectiveness of an
5 online-delivered physical activity intervention for increasing regular walking among rural adults in
6 South Australia.

7 **Design:** Randomised controlled study design.

8 **Methods:** A randomised controlled trial consisting of a twelve-week intervention, with six- and
9 twelve-month follow-ups, was conducted. Participants (n=171; 50.6±12.5 y) were randomised to
10 comparison or intervention groups and received a pedometer. The intervention group received
access

11 to the purpose-built REACH website and received personalised step goals based on ratings of
12 perceived exertion and daily affect. The comparison group received a standard paper diary and
generic

13 step goals. Primary outcome measures were sedentary, light (LPA) and moderate-to-vigorous
(MVPA)

14 physical activity, measured by accelerometry. Linear mixed models assessed change in outcomes
over

15 the intervention and follow-up.

16 **Results:** Sedentary time was reduced, and LPA and MVPA increased in both groups across the
17 twelve-week intervention ($p<0.05$). The intervention group demonstrated a larger increase in LPA
at

18 six-month follow-up relative to comparison ($p<0.05$). Both groups decreased sedentary time,
overall

19 and in bouts ≥ 30 min, and increased MVPA bouts (≥ 10 min) across the intervention.

20 **Conclusion:** The provision of a pedometer and step goals led to increases in physical activity and
21 reduced sedentary time. The inclusion of individualised step goals and website improved
maintenance

22 of LPA at follow-up. Additional research is needed to identify ways to improve long-term
adherence.

23

24 **Trial registration** Australian New Zealand Clinical Trials Registry: ACTR12614000927628

25 (registered 28 August 2014). **Keywords:** rural health; walking; pedometer; internet;
accelerometer;

26 randomized controlled trial.

***Manuscript (excluding all author details and affiliations)**

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27 Introduction

28 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^{1,29}.

30 More recently, independent contributions of prolonged sedentary behaviour to cardiometabolic
health

have been highlighted³¹. Yet interventions to promote physical activity and reduce sedentary
behaviour

remain largely unsuccessful³².

33 In Australia, 63% and 65% of rural men and women, respectively, are insufficiently active,
compared

to 55% and 60% in major cities³⁴. This may be partly attributable to challenges implementing
35 community-based physical activity promotion in rural regions that experience greater social
isolation

and lower access to services and physical activity opportunities³⁶. With lower life expectancies and

poorer health across a range of chronic conditions⁶³⁷, rural adults are a population for whom
appropriately designed and implemented physical activity promotion is urgently needed.
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 interventions⁷ and internet interventions⁸⁴¹, REACH was
theoretically driven, drawing upon Social Cognitive (SCT), Goal Setting (GST) and Self-
Determination (SDT) 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 response⁹⁴⁶. 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, 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.

60 **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

elsewhere¹⁰⁶⁷. The protocol was approved by the University of South Australia Human Research
Ethics

Committee and all participants provided informed written consent.

Participants were recruited using local print and electronic media 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.

73 Eligible participants were aged 18-70 years and resident in one of the regions for at least twelve
74 months. According to self-report, they had participated in fewer than 20 bouts of physical activity
of

75 ≥ 20 minutes in the preceding month. Potential participants were screened for eligibility via
telephone

76 and completed pre-exercise assessments.

77 At all time-points, participants underwent seven days of physical activity monitoring and a series
of

health and anthropometric assessments¹⁰78 . Following baseline assessments, participants were
randomised into the comparison or intervention group by 79 clustered randomisation. This was done
as

80 participants often enquired about the study in small groups and maintaining these groups would
reduce

81 contamination and drop-out.

82 At baseline, separate information sessions were held for intervention and comparison participants,
83 during which the importance of regular physical activity was emphasised and pedometers (Yamax
84 DW700) were distributed for use during the intervention period. Comparison participants were
issued

85 a paper step diary to be filled out daily while intervention participants were shown how to use the
86 REACH website.

87 The REACH intervention comprised three key components: the REACH website, weekly
personalised

88 step goals and ongoing telephone support. The intervention group received access to the REACH
89 website where they recorded daily steps, presented on a continually updated graph to provide
feedback

90 visually. Participants recorded their Rating of Perceived Exertion (RPE) during exercise using
Borg's

6-20 Ratings of Perceived Exertion (RPE) Scale^{11, p.31} 91 and their daily affective state (i.e. feelings of
pleasure or displeasure) when they rose from bed each morning, using the Feelings Scale¹²92 .

Affective

state has been shown to significantly influence exercise behaviour and motivation¹³93 .

94 The website enabled participants to share experiences with other intervention group members. A
95 virtual notice board collated information on local community events and services, walking groups
and

96 other region-specific information. The website also provided access to healthy eating guidelines
based

on the current Australian nutritional guidelines¹⁴97 .

98 Supportive telephone calls (approximately 15 min), following the spirit of motivational
interviewing,

99 were provided to the intervention group in weeks two, four, seven and ten of the intervention.

100 Conversations provided feedback on progress, website use, perceived barriers, injury/illness,
correct

101 interpretation of RPE and affect, and reinforcement of advice for increasing physical activity
through

102 incorporation into daily routines. Detailed notes were maintained so subsequent calls could
address

103 specific issues for each participant.

Personalised step goals were created for each upcoming week 104 using the recorded steps, RPE and
affect

105 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 individual¹⁵, but one that would result in a positive affective response during exercise¹⁶. 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 most days, the goals for the following week did not increase, and in some cases, were reduced. If a given week's goals were consistently met, 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 steps¹⁷ 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; Equation 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-points¹⁸ (sedentary <377, light <806, moderate <2263 and vigorous ≥ 2263 g.min adjusted for the sampling frequency). [Equation 1] signal Vector Magnitude gravity corrected VM

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 and 10 mins, respectively, and the average number of sedentary and MVPA bouts per day, were calculated, to align outcomes with current physical activity recommendations¹⁹.

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 $\times$ time interaction term was added to the models. Analyses were performed using Stata (version 14; StataCorp LP, TX) with significance inferred if $p < 0.05$.

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).

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.

Figure 1 illustrates the changes in total sedentary and physical activity minutes over the intervention

and follow-up periods. After adjustment for age and sex, 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.

Moreover, there were larger increases in LPA in the intervention group than the comparison group at

six-month follow-up (Figure 1B and supplementary material 2). For MVPA, between baseline and

twelve-month follow-up there was a near significant group $\times$ time interaction ($p = 0.086$) suggesting

more pronounced declines beyond the intervention period in the comparison than the intervention group (Figure 1C and supplementary material 2).

Figure 2 illustrates the changes in bouts of sedentary (≥ 30 min) and MVPA (≥ 10 min) by group. 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 12

months in both groups. The group $\times$ time interaction for number and duration of MVPA bouts reached

near significance at the twelve month follow-up ($p = 0.079$ and 0.083 respectively), indicating larger

reductions in the comparison group than the intervention group (Figure 2B and 2D).

173

174 **Discussion**

175 Despite the obvious benefits of increasing physical activity to reduce the risk of chronic lifestyle
176 related diseases, a recent meta-analysis of physical activity promotion among rural adults has
demonstrated approaches to increase physical activity are largely ineffective²⁰¹⁷⁷. Alarming, only
four

178 of the twelve studies included follow-up measures beyond the intervention, underscoring how
little is

currently known about effective physical activity 179 behaviour change and maintenance of change
in

180 rural adults. In response to this gap, the current study tested the impact of a more nuanced and
181 personalised goal setting intervention for behaviour change, along with the central role of choice
and

182 autonomy in the development of intrinsically driven motivation to maintain improved behaviours
183 among rural Australians.

184 Whilst favourable changes occurred in all measured behaviours from the baseline to the end of
the

185 intervention, no differences were observed between groups. This is perhaps unsurprising as
186 participants volunteered into the study and were therefore likely to be already motivated to
change.

187 Further, the comparison group received a standard intervention ‘dose’ comprising education on
the

188 benefits of physical activity, non-personalised incremental goal setting and a diary to log steps, a
189 pedometer, and feedback by providing their health test results at each time point. However, in
line

190 with our hypothesis, the results demonstrate a tendency for better maintenance of favourable
191 behaviours beyond the intervention period among the intervention group, most notably for LPA
at six¹⁹²

month follow-up, with an indication of better MVPA maintenance at twelve-month follow-up. The
193 only difference in exposure between groups was engagement with the REACH website, which
was

194 primarily designed according to key elements of SCT and SDT. The results add to the growing
195 evidence supporting autonomy and more self-determined sources of motivation for maintaining
improved physical activity behaviours. A systematic review of 66 studies²¹ 196 concluded there is
197 consistent support for a positive relationship between autonomous forms of regulation and
exercise

198 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 intervention²²¹⁹⁹.

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

metabolic syndrome (MetS)²³²⁰¹. Light-intensity physical activities such as walking for transport,
leisure

or occupational purposes, are the major source of variability in daily energy expenditure²⁴²⁰².

Together,

203 these observations support targeting LPA in population-level health promotion. As sedentary
time and

204 LPA were highly inversely correlated in the current study ($r = -0.61$, $p < 0.0001$ at baseline),
public

205 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 years¹⁹, 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.

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, 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. 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 and colleagues’²⁰ 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 adults²⁰, 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 adults²⁶ 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 minutes 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 correlations²⁷. Self-report outcomes reflect perceived time-use and intensity of effort

while accelerometry-based activity monitors derive outcomes from patterns of movement; these

237 outcomes are not based on the same construct and therefore results from the two measures are not interchangeable^{28,238} .

239 Accelerometer output was presented as time spent in different intensities of PA using published cutpoints

for sedentary, LPA and MVPA^{18,240} . An independent cross-validation of these cut-points reported modest validity^{29,241} , but it is well documented that PA outcomes can differ substantially depending on

the choice of epoch length and cut-point^{30,242} . As these cut-points were applied to both groups at repeated

243 time points, this will not have impacted the outcomes of the study, but comparability to studies using

244 different cut-points may be limited.

245

246 Conclusion

247 The search continues for strategies to increase physical activity and reduce sedentary behaviours, particularly in at-risk populations such as rural adults. REACH is a computer-delivered strategy designed to address specific challenges to physical activity promotion in rural communities, namely

250 social isolation and poor access to facilities and expertise to guide behaviour change. The results of the

251 trial were promising, particularly in relation to LPA which has demonstrated associations with cardiometabolic health^{23,252} . However, regression to baseline for most measured behaviours at longer

253 term follow-up highlights the need for economically feasible, acceptable adaptations to the protocol

254 that strengthen self-determination in the development of a life-long habit of physical activity.

255

256 Practical Implications

257 • The use of an online delivered physical activity intervention may provide a cost-effective method for increasing physical activity behaviour in rural populations,

259 • 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

262 • 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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