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Examining moderators of the effectiveness of a web- and video-based computer-tailored physical activity intervention

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ABSTRACT

Understanding for whom behaviour change interventions work is important, however there is a lack of studies examining potential moderators in such interventions. This study investigated potential moderators on the effectiveness of a computer-tailored intervention to increase physical activity among Australian adults. People who had <150 min of moderate-vigorous physical activity (MVPA) a week, able to speak and read English, aged ≥18 years, lived in Australia, and had internet access were eligible to participate. Participants recruited through social media, emails, and third-party databases, were randomly assigned to either the control (n = 167) or intervention groups (n = 334). Physical activity was measured objectively by ActiGraph GT3X and also by self-report at baseline and three months. Three-way interaction terms were tested to identify moderators (i.e., demographic characteristics, BMI, and perceived neighbourhood walkability). The results showed that the three-way interaction was marginally significant for sex on accelerometer measured MVPA/week (p = 0.061) and steps/day (p = 0.047). The intervention appeared to be more effective for women compared to men. No significant three-way interactions were found for the other potential moderators. Strategies to improve levels of personalisation may be needed so that physical activity interventions can be better tailored to different subgroups, especially sex, and therefore improve intervention effectiveness.

1. Introduction

Physical inactivity is associated with multiple health conditions including cardiovascular diseases, diabetes, and cancer (Physical Activity Guidelines Advisory Committee, 2018). However, more than half of Australian adults do not meet the recommendation of 150 min of moderate-vigorous intensity physical activity (MVPA) per week (Australian Institute of Health and Welfare, 2017). To address this issue, population-based interventions that can reach large numbers of people at an affordable cost are being developed and evaluated. This context has seen the development of web-based computer-tailored interventions. Computer-tailored interventions mimic face-to-face interactions with health professionals and are able to provide detailed and personally relevant behaviour change information to large numbers of web-users (Vandelanotte et al., 2018). Personalised physical activity advice is provided after participants complete brief online surveys. Relevant feedback is selected from a large database based on participants' responses (Vandelanotte et al., 2017). It has been found that 20 out of 29 (70%) computer-tailored interventions are significantly more effective at increasing physical activity compared to websites providing generic information ('one-size-fits-all') (Broekhuizen et al., 2012). While many computer-tailored interventions have been evaluated, few of those have examined to what extent their effectiveness was influenced by moderators.

Moderators are factors that modify the strength of a relationship (Bauman et al., 2002). In this case, the relationship of interest is whether an intervention was effective in improving health behaviours and moderators are factors modifying this effectiveness. For example, sex is a

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moderator if the effect of the intervention is different for men and women. Moderators are important factors to investigate as they can provide insight about for whom the intervention was most effective. This information can be used to improve the intervention for sub-populations it does not work well for, or to implement the intervention for whom it works best. Investigating moderators is also necessary even when interventions were found ineffective, as it may be that effectiveness in some subgroups was masked by ineffectiveness in other subgroups. As moderators play an important role in modifying effects of health behaviour change, understanding behaviour change mechanisms of interventions is not complete without knowledge of moderators (Baranowski and Jago, 2005).

The model of user engagement in online behaviour change interventions by Short et al. was used as guidance to select the moderators (Short et al., 2015). These potential moderators include age, sex, socioeconomic status (SES), and BMI. Due to differences in physical activity motivation, preferences and behaviour, it is possible that an intervention may benefit men and women as well as younger and older adults differently. Some studies have shown that women respond better to health behaviour interventions compared to men (Luten et al., 2016; Yildirim et al., 2011; Kremers et al., 2007) and those aged 60+ years increased their physical activity more than younger groups (Ammann et al., 2013). Socio-economic status (SES) represented by education level, income, and employment status may also moderate the intervention effects, as those with lower SES may have less opportunities engaging in physical activity and therefore may benefit more from the intervention (Luten et al., 2016; Yildirim et al., 2011; van Stralen et al., 2010). In addition, another potential moderator is neighbourhood walkability with two studies showing that people living in more walkable neighbourhoods benefited more from physical activity interventions (Perez et al., 2017; Gebel et al., 2011), and one study finding that overweight men living in less walkable neighbourhoods increased their walking more (Kerr et al., 2010). BMI may also be a moderator, as a review has shown that people with a lower baseline BMI tend to adhere more to lifestyle interventions Burgess et al., (2017). Although moderation effects of these factors were previously investigated (Luten et al., 2016; Yildirim et al., 2011; Kremers et al., 2007), there is a lack of studies examining these effects in web-based behaviour change interventions. Among two web-based studies conducted in older adults, only one was computer-tailored (Luten et al., 2016; van Stralen et al., 2010). Other studies were almost exclusively conducted among children and youths (Yildirim et al., 2011; Kremers et al., 2007).

Given the lack of data on the topic, this study aims to investigate demographic characteristics, BMI, and perceived neighbourhood walkability as potential moderators on the effectiveness of a computer-tailored intervention to increase physical activity among Australian adults. We hypothesize that the intervention is more effective for women, adults 45 years or older, non-overweight participants, those with lower SES, and living in less walkable neighbourhoods.

2. Methods

2.1. Study design

This study used data from a computer-tailored physical activity intervention, the TaylorActive trial, aiming to increase physical activity among adults in Australia. Details and protocols have been published elsewhere (Vandelanotte et al., 2015). Briefly, the study is a randomised controlled trial with three groups: a video-tailored, a text-tailored, or a control group. The text-tailored group received eight physical activity sessions delivered as personalised text on a webpage; and the video-tailored group received the same eight sessions delivered as personalised videos over three months. The video and text tailored advice were delivered at the same schedule and through a web-based platform. Text- and video-tailored groups also had access to six online sessions to formulate action plans during the three months. All groups had access to a web-based library with text-based generic physical activity information. This was accessible via a link on the home page. Multiple behaviour change theories including Theory of Planned Behaviour Ajzen (1985), Self-Determination Theory (Ryan and Deci, 2000), and Social Cognitive Theory (Bandura, 1986) were used as guidance for the intervention. Assessments were conducted at baseline, three months, and nine months.

2.2. Participants and procedures

Participants were included if they were able to speak and read English, aged ≥18 years, lived in Australia, had internet access, and engaged in <150 min of MVPA/week. Those who were pregnant, had BMI < 18.5, or had a health condition (assessed by the Physical Activity Readiness Questionnaire (Cardinal et al., 1996) preventing them from safely increasing their physical activity level were excluded.

Recruitment was conducted through social media including Facebook, newspapers, and radio. Emails and third-party databases (e.g. trialfacts.com) were also used for recruitment. A link was provided in advertisements directing interested people to a webpage where they could find study information and contact the research team. Those who were interested in participating were asked to answer online screening questions for eligibility assessment and if eligible, to complete an online consent form.

After verifying the provided information, a package including an accelerometer with instructions on how to use it, a wear-time log, an information sheet, and a return post-bag was mailed to participants. They were asked to wear the device for seven consecutive days. Trained and blinded interviewers from CQUniversity's Population Research Laboratory collected self-reported data using Computer Assisted Telephone Interviewing. Participants with complete baseline data were allocated to groups using random sequences generated via www.randomization.com. There were 501 participants randomised to three groups (167 per group) at baseline. At 3 months, assessments were completed by 104, 83, 72 participants in the control, text-tailored, and video-tailored groups respectively. Of those formally withdrawing from the trial (n = 144), the main reason was loss of interest (n = 98). A complete CONSORT diagram can be found elsewhere (Vandelanotte et al., 2020).

2.3. Measures

2.3.1. Physical activity outcomes

Physical activity was measured objectively using ActiGraph GT3X and also by self-report. ActiGraph GT3X is a triaxial accelerometer that was worn on the right hip using a provided elastic waistband. Participants were asked to wear the GT3X for seven consecutive days, keep it dry, and complete an activity log indicating non-wear time. The GT3X records both intensity counts and steps. The units were set up with a sampling rate of 30 Hz and intensity counts were aggregated to 1-minute epoch using ActiLife software. Non-wear time was defined as 90 consecutive minutes of zero count/min. Wear time of ≥600 min/day on ≥5 days was considered valid in this study (Troiano et al., 2014). Participants who did not meet the criteria were asked to wear the monitor again. Those who refused or failed to return valid data after 3 attempts were excluded from the study. The triaxial accelerometer vector magnitude threshold to classify an activity as MVPA was ≥2690 counts/min (Sasaki et al., 2011).

Self-reported physical activity data were collected using eight questions from the Active Australia Survey(Australian Institute of Health and Welfare, 2003). This survey, which has been validated among the Australian adults (Brown et al., 2004), provides contextual information by asking about frequency and duration of different activities including walking, moderate-intensity and vigorous-intensity physical activity in the last week. The total physical activity time is a sum of time spent being active at all intensities, with vigorous intensity physical activity time doubled (Australian Institute of Health and Welfare, 2003). Walking time was also used as a separate outcome in the analysis.

2.3.2. Potential moderators

Demographic characteristics including sex, age, years of schooling, employment, household income per week and marital status were self-reported. Median values were used to categorise age into "<45 years" or "≥45 years" and years of schooling into "<16 years" or "≥16 years". The other variables were also dichotomised with employment grouped into "Full time" or "Not full time", household income into "<$2200/week" or "≥2000/week", and marital status into "Not in a relationship" or "In a relationship".

Body Mass Index (BMI) was calculated by weight(kg)/height(m^2) with weight and height self-reported. Participants with a baseline BMI ≥ 25 were classified as overweight/obese; otherwise, they were classified as not overweight. The use of web-based self-reported height, weight, and BMI are common in web-based studies and was found to have moderate to high agreement with the objective measures (Pursey et al., 2014).

Neighbourhood walkability was assessed using 12 items from the Physical Activity Neighbourhood Environment Scale (PANES) (Sallis et al., 2010). This valid and reliable tool measures neighbourhood characteristics including land mix use, street connectivity, residential density, traffic safety, crime, infrastructure/facilities, and aesthetic qualities (Sallis et al., 2010). With the exception of item 1 asking about type of housing, responses for the other items are based on a 4-point Likert scale ranging from strongly disagree to strongly agree. Accordingly, scores for each item ranges from one to four. For participants answering at least 9 items (75%), an average score was calculated. Data for those responding to<9 items was not included in the analyses. Participants were classified into "Low walkability" if the score was <3.2 points or "High walkability" if ≥3.2 points.

2.4. Analysis

SAS v9.4 was used for analysis. As no significant intervention effect was observed at three and nine months between the intervention groups in the randomised controlled trial (Vandelanotte et al., 2020), the intervention groups were combined in the analysis to maximize power and simplify the interpretation of the results. In addition, due to a high attrition at nine months (69%), only data from baseline and assessments at three months were used. Means and standard deviations (SD) were calculated for each outcome (i.e., ActiGraph measured MVPA per week, ActiGraph measured steps per day, total self-reported physical activity time/week, and self-reported walking time per week) and presented for each time point.

Generalised linear mixed models with random subject effect, gamma distribution and log link were run separately for each outcome and each potential moderator. Each model included group, time, the potential moderator, activity monitor wear-time, the two-way interaction terms (group × time, group × moderator, time × moderator), and a three-way interaction term (group × time × moderator). Empirical estimator was used to obtain robust standard errors. Although the main interest of this study was the overall effects of the three-way interaction terms that indicate whether effectiveness of the intervention differed between levels of the moderator, estimates reported for between-group differences were adjusted for multiple comparisons using simulation option available in PROC GLIMMIX. Means ratios (95%CI) were presented for each level of moderators. All p-values were two-sided, and the significance level was set at <0.05.

3. Results

3.1. Baseline sample characteristics

A total number of 501 participants was randomly assigned to either the control group (167 participants) or intervention group (334 participants). Table 1 shows baseline characteristics by study groups. The majority of the participants were female, in a relationship, overweight/obese, and had ≥16 years of schooling. About half of participants had full-time jobs. The characteristics were similar between the two groups with the exception of weight status. The proportion of participants who were overweight/obese was higher in the control group (74.7%) compared to the intervention group (63.3%).

3.2. Outcome description by group and time

Table 2 presents means and SD for each physical activity outcome by group at baseline and three months. At baseline, men in the intervention and control groups had on average 150.8 (SD = 160.8) and 99.2 (SD = 70.4) accelerometer measured minutes of MVPA per week respectively; women had 93.8 (SD = 90.5) and 89.2 (SD = 98.2) minutes respectively. At 3-months, men in the intervention and control group had on average 132.3 (SD = 97.8) and 129.8 (SD = 95.2) accelerometer measured minutes of MVPA per week respectively; women had 124.0 (SD = 101.9) and 108.8 (SD = 94.9) minutes respectively. Those <45 years in the intervention and control group at baseline had on average 126.2 (SD = 115.6) and 99.5 (SD = 103.6) accelerometer measured minutes of MVPA per week respectively; those ≥45 years had 91.3 (SD = 114.3) and 84.7 (SD = 76.7) minutes respectively. Those <45 years in the intervention and control group at 3-months had on average 125.5 (SD = 102.8) and 110.7 (SD = 101.9) accelerometer measured minutes of MVPA per week respectively; those ≥45 years had 127.3 (SD = 98.6) and 119.0 (SD = 90.3) minutes respectively.

Table 1
Baseline characteristics by treatment group.

	Control		Intervention	
	N	%	N	%
Sex				
Male	46	27.5	94	28.1
Female	121	72.5	240	71.9
Age group				
<45 years	85	50.9	175	52.4
≥45 years	82	49.1	159	47.6
Weight status				
Non-overweight	42	25.3	122	36.7
Overweight/Obese	124	74.7	210	63.3
Years of schooling				
<16 years	62	37.1	142	42.5
≥16 years	105	62.9	192	57.5
Employment				
Full time	88	52.7	173	52.0
Not full time	79	47.3	160	48.0
Household income				
<2000/week	82	53.6	137	50.4
≥2000/week	71	46.4	135	49.6
Marital status				
Not in a relationship	48	28.7	106	31.7
In a relationship	119	71.3	228	68.3
Walkability				
Low (<3.2 points)	69	41.8	164	49.2
High (≥3.2 points)	96	58.2	169	50.8

Table 2
Means and Standard Deviations (SD) for each outcome by group at baseline and 3-months.

	Accelerometer measured MVPA (min/week)				Accelerometer measured Steps/day				Self-reported total physical activity (min/week)				Self-reported walking time (min/week)			
	Control		Intervention		Control		Intervention		Control		Intervention		Control		Intervention	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
Overall																
Baseline	159	92 (91.1)	307	109 (116.1)	159	7000.1 (2241.6)	307	7193.2 (2486.2)	167	197.8 (208.8)	334	192.3 (200.1)	167	92.7 (97.3)	334	91 (109.6)
3-Months	82	115.5 (94.9)	135	126.4 (100.5)	82	7465.8 (2401.7)	135	7801.9 (2473.1)	104	246.7 (246.7)	155	331.5 (273.2)	104	119.5 (125.6)	155	144.2 (143.7)
Sex																
Male																
Baseline	45	99.2 (70.4)	82	150.8 (160.8)	45	6716.1 (1938.2)	82	7642.2 (2893.5)	46	239.9 (227.0)	94	198.0 (186.9)	46	74.5 (75.2)	94	87.0 (101.0)
3-Months	26	129.8 (95.2)	39	132.3 (97.8)	26	7586.8 (2589.2)	39	7466.6 (2875)	31	283.4 (312.6)	45	317.7 (214.5)	31	117.9 (92.5)	45	134.7 (125.3)
Female																
Baseline	114	89.2 (98.2)	225	93.8 (90.5)	114	7112.2 (2349.1)	225	7029.5 (2305.6)	121	181.7 (200.1)	240	190.0 (205.4)	121	99.6 (104.0)	240	92.5 (112.9)
3-Months	56	108.8 (94.9)	96	124.0 (101.9)	56	7409.6 (2331.9)	96	7938.2 (2292.6)	73	231.1 (213.3)	110	337.2 (294.6)	73	120.1 (137.8)	110	148.1 (150.9)
Age group																
<45 years																
Baseline	79	99.5 (103.6)	156	126.2 (115.6)	79	7032.5 (2182.7)	156	7544.9 (2489.9)	85	185.2 (194.4)	175	202.3 (201.0)	85	85.5 (98.6)	175	92.3 (115.7)
3-Months	35	110.7 (101.9)	70	125.5 (102.8)	35	7441.3 (2322.3)	70	7668.0 (2234.1)	48	233.0 (228.3)	83	296.7 (257.0)	48	121.7 (138.1)	83	132.3 (140.7)
≥45 years																
Baseline	80	84.7 (76.7)	151	91.3 (114.3)	80	6968.1 (2311.6)	151	6829.8 (2437.5)	82	210.8 (223.2)	159	181.3 (199.2)	82	100.1 (96.1)	159	89.5 (102.7)
3-Months	47	119.0 (90.3)	65	127.3 (98.6)	47	7484.0 (2484.0)	65	7946.1 (2717.3)	56	258.4 (262.8)	72	371.7 (287.4)	56	117.6 (115.1)	72	157.8 (146.8)
Weight status																
Non-Overweight																
Baseline	41	128.6 (125.8)	114	129.7 (115.8)	41	7342.7 (2589.1)	114	7851.6 (2597.4)	42	253.8 (264.2)	122	193.1 (179.7)	42	106.9 (113.7)	122	88.8 (88)
3-Months	24	140.6 (99.4)	47	132.9 (99.3)	24	8230.8 (2603.0)	47	8145.7 (2178.5)	29	283.6 (218.3)	54	370.3 (331.9)	29	121.2 (106.6)	54	157.6 (183.9)
Overweight/Obese																
Baseline	117	79.6 (72.1)	191	95.9 (115.1)	117	6892.6 (2112.0)	191	6798.9 (2348.1)	124	179.6 (184.5)	210	190.5 (212)	124	88.6 (91.2)	210	91.3 (120.5)
3-Months	57	105.6 (92.6)	86	120.6 (101.3)	57	7188.4 (2261.7)	86	7620.3 (2624.9)	74	233.1 (258.4)	99	308.1 (236)	74	120.4 (133.1)	99	136.5 (118.2)
Schooling																
<16 years																
Baseline	60	74.1 (75.6)	131	94.9 (95.2)	60	7021.6 (2376.7)	131	7071.0 (2481.8)	62	166.8 (213.5)	142	168.1 (191.2)	62	70.6 (74.8)	142	79.5 (101.6)
3-Months	29	102.2 (88.3)	47	129.1 (86.8)	29	7702.1 (2784.1)	47	7929.0 (2836.0)	37	275.4 (302.4)	58	360.0 (255.3)	37	115.1 (147.3)	58	136.6 (125.0)
≥16 years																
Baseline	99	102.9 (98.1)	176	119.5 (128.8)	99	6987.0 (2167.9)	176	7284.1 (2492.6)	105	216.0 (204.7)	192	210.1 (205.2)	105	105.7 (106.7)	192	99.4 (114.6)
3-Months	53	122.8 (98.3)	88	125 (107.5)	53	7336.5 (2182.5)	88	7734.1 (2270.4)	67	230.8 (210.6)	97	314.5 (283.4)	67	121.9 (113.0)	97	148.8 (154.2)
Employment																
Full time																
Baseline	85	94.6 (93.9)	157	113.9 (123.1)	85	7015.2 (2243.3)	157	7206.5 (2734.7)	88	172.6 (191.5)	173	182.1 (173.1)	88	78.5 (101)	173	86 (105.3)
3-Months	44	111.8 (102.7)	72	136.9 (97.9)	44	7368.9 (2010.9)	72	7949.5 (2531.5)	50	250.6 (270.6)	83	324.8 (242.8)	50	107.9 (89.5)	83	139.7 (128.8)
Not full time																
Baseline	74	89.1 (88.3)	149	104.3 (108.8)	74	6982.8 (2254.8)	149	7200.8 (2196.9)	79	225.8 (224.4)	160	204.3 (225.9)	79	108.5 (91.1)	160	96.9 (114.1)
3-Months	38	119.7 (86.2)	63	114.4 (102.7)	38	7578 (2811.4)	63	7633.2 (2413.7)	54	243.1 (224.7)	72	339.2 (306.2)	54	130.2 (151.7)	72	149.4 (159.8)
Household income																
<$2000/week																
Baseline	79	89.7 (73.5)	131	114.8 (125.9)	79	7024.9 (1999.4)	131	7273.7 (2527.3)	82	211.7 (232.2)	137	206.6 (204.6)	82	87.9 (87)	137	92.6 (106)
3-Months	47	121.7 (95.6)	60	136.9 (108.3)	47	7780.8 (2349.8)	60	8062.5 (2316.8)	54	251.2 (220.8)	71	329.4 (260.1)	54	123.6 (100.8)	71	134.9 (112.3)

(*continued on next page*)

Table 2 (*continued*)

	Accelerometer measured MVPA (min/week)				Accelerometer measured Steps/day				Self-reported total physical activity (min/week)				Self-reported walking time (min/week)			
	Control		Intervention		Control		Intervention		Control		Intervention		Control		Intervention	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
≥$2000/week																
Baseline	66	85.9 (90.5)	119	103 (108.9)	66	6762.9 (2417.3)	119	7130.3 (2484)	71	164.6 (170.1)	135	189.9 (213.5)	71	82.8 (80.6)	135	91.8 (122.8)
3-Months	31	107.1 (98)	61	109.9 (91.3)	31	6871 (2508.2)	61	7572 (2595.6)	45	216.4 (214.6)	67	332.1 (284.3)	45	108.4 (151.8)	67	143.7 (164.8)
Marital status																
Not in a relationship																
Baseline	47	103.3 (122.5)	95	121.2 (131.4)	47	7084.8 (2925.6)	95	7017.4 (2588.8)	48	192.7 (194.9)	106	189.2 (217.2)	48	117.6 (122.9)	106	104 (136.9)
3-Months	25	109.6 (96.5)	35	121.6 (92.9)	25	6878.2 (2396.9)	35	7135.3 (1895.9)	35	204.9 (206.4)	41	278.5 (207.4)	35	112.3 (129.5)	41	151 (154.5)
In a relationship																
Baseline	112	87.3 (74.3)	212	103.6 (108.5)	112	6964.5 (1897.6)	212	7271.9 (2440.9)	119	199.8 (214.9)	228	193.7 (192.2)	119	82.6 (83.4)	228	84.9 (93.9)
3-Months	57	118.1 (94.9)	100	128.1 (103.4)	57	7723.5 (2378.9)	100	8035.3 (2613.8)	69	267.9 (263.6)	114	350.6 (291.8)	69	123.1 (124.4)	114	141.8 (140.2)
Walkability																
Low (<3.2 points)																
Baseline	64	70.1 (58.2)	148	84.8 (87.4)	64	6467.2 (1742.1)	148	6800.3 (1981.6)	69	146.4 (157.4)	164	153.8 (170.9)	69	73.3 (85.7)	164	77.2 (94.9)
3-Months	31	104.1 (96.2)	73	113.1 (96.8)	31	7087.1 (2338.4)	73	7652.5 (2523.3)	39	228.8 (212.4)	79	320 (284.2)	39	117.2 (157.1)	79	128.3 (146)
High (≥3.2 points)																
Baseline	93	108.8 (105.8)	158	132.3 (134.1)	93	7308.8 (2263)	158	7556.8 (2844.1)	96	237.5 (233.3)	169	230.8 (218.9)	96	107.3 (103.5)	169	104.8 (120.9)
3-Months	50	123.3 (95.1)	6 2	142.1 (103.2)	50	7764.9 (2407.2)	62	7977.9 (2421.2)	64	258.6 (268.1)	76	343.5 (262.7)	64	122.7 (103.2)	76	160.7 (140.3)

3.3. Moderation effects

Table 3 shows means ratios (95% CI) between intervention and control groups with baseline measures as a reference. The three-way interaction was marginally significant for sex on two physical activity outcomes: accelerometer measured MVPA time/week ($p = 0.061$) and steps/day ($p = 0.047$). However, a consistent, but non-significant, pattern was also identified for self-reported total physical activity ($p = 0.608$) and walking time ($p = 0.334$). The intervention appeared to be more effective for women with increases at three months ranging from 5% for accelerometer measured MVPA time/week and steps/day to 45% for self-reported total physical activity time. For men, decreases at three months in MVPA time, steps/day, and walking time, and a smaller increase in total physical activity time (26%) were observed. Fig. 1 provides a visual illustration for changes in MVPA time/week and steps/day for male and female by study group. The three-way interactions were not statistically significant for age group, neighbourhood walkability, years of schooling, weight status, employment, and marital status, and household income.

4. Discussion

This study aimed to investigate demographic characteristics (i.e., sex, age, years of schooling, employment, household income/week, and marital status), BMI, and perceived neighbourhood walkability as potential moderators on the effects of a computer-tailored physical activity intervention to increase physical activity among Australian adults. The findings showed that sex was the only statistically significant moderator. For other variables, including age group, neighbourhood walkability, weight status, years of schooling, employment status, marital status and household income, the results were not statistically significant.

Although many studies have investigated sex as a potential moderator on physical activity intervention effects among youths (Yildirim et al., 2011; Kremers et al., 2007), fewer studies were conducted among adults (Luten et al., 2016; van Stralen et al., 2010). In general, women seemed to respond better to health behaviour interventions compared to men (Luten et al., 2016; Yildirim et al., 2011; Kremers et al., 2007). This is consistent with our findings. A possible explanation may be due to differences in physical activity motivation and preferences. While men are often motivated more by competitive activities, women tend to be motivated more by health and appearance (Egli et al., 2011). As the intervention primarily promoted general physical activity, not structured exercise, it may have been more attractive to women. Another explanation may be that the participants were not successfully randomised into groups at baseline as men in the control group had a much lower level of accelerometer measured MVPA at baseline compared to the intervention group (as illustrated in Fig. 1). As a result, there may not have been sufficient room for men in the intervention group to increase their physical activity level. The conflation of these issues makes it more difficult to assess whether the intervention itself did not work for men and if an additional component specifically targeting men could have been helpful to improve intervention effectiveness in men. However, interventions that are specifically designed for men may be more effective (Morgan et al., 2012; Caperchione et al., 2012; Vandelanotte et al., 2013). Further studies including formative research investigating this issue is needed.

Age is an important factor that has significant impact on physical activity. Studies have shown a decline in adults' physical activity over time (Trost et al., 2002; Guthold et al., 2008). However, only a few studies investigated moderation effects of age on physical activity interventions. Several studies were not able to find a significant moderation effect for age (Luten et al., 2016; van Stralen et al., 2010). In contrast, Ammann et al. 2013 showed that those aged 60 years or older participating in a tailored, web-based physical activity intervention increased their physical activity more than younger groups (Ammann et al., 2013). In this study, no moderation effect for age was found. A

Table 3
Means Ratios (95% CI) between intervention vs. control groups with baseline as reference.

	Accelerometer measured		Self-reported	
	MVPA (min/week)	Steps/day	Total time (min/week)	Walking time (min/week)
Sex				
Male	0.70* (0.50, 0.99)	0.90** (0.79, 1.03)	1.26 (0.79, 1.99)	0.94 (0.61, 1.45)
Female	1.05 (0.82, 1.33)	1.05 (0.97, 1.14)	1.45 (1.09, 1.92)	1.22 (0.89, 1.67)
Age group				
<45 years	0.87 (0.66, 1.16)	0.96 (0.86, 1.06)	1.16 (0.79, 1.72)	0.98 (0.66, 1.45)
≥45 years	1.00 (0.76, 1.32)	1.06 (0.97, 1.16)	1.65 (1.22, 2.23)	1.30 (0.94, 1.80)
Weight status				
Non-Overweight	1.01 (0.72, 1.42)	0.97 (0.86, 1.09)	1.64 (1.10, 2.47)	1.25 (0.82, 1.9)
Overweight/Obese	0.90 (0.70, 1.15)	1.03 (0.94, 1.12)	1.28 (0.94, 1.74)	1.09 (0.79, 1.51)
Years of schooling				
<16 years	1.07 (0.76, 1.52)	1.05 (0.92, 1.18)	1.52 (1.03, 2.23)	1.06 (0.7, 1.58)
≥16 years	0.86 (0.68, 1.09)	0.99 (0.91, 1.07)	1.32 (0.97, 1.79)	1.17 (0.85, 1.61)
Employment				
Full time	0.92 (0.72, 1.18)	1.03 (0.94, 1.14)	1.27 (0.9, 1.79)	1.04 (0.76, 1.44)
Not full time	0.93 (0.68, 1.28)	0.98 (0.88, 1.08)	1.49 (1.05, 2.11)	1.22 (0.82, 1.82)
Household income				
<2000/week	0.83 (0.65, 1.08)	1.01 (0.92, 1.11)	1.47 (1.07, 2.01)	1.04 (0.76, 1.43)
>=2000/week	0.99 (0.71, 1.37)	1.01 (0.91, 1.13)	1.24 (0.84, 1.82)	1.17 (0.75, 1.83)
Marital status				
Not in a relationship	0.88 (0.61, 1.29)	1.02 (0.89, 1.16)	1.55 (0.99, 2.44)	1.40 (0.83, 2.37)
In a relationship	0.94 (0.75, 1.19)	1.00 (0.92, 1.09)	1.30 (0.98, 1.73)	1.05 (0.79, 1.39)
Neighbourhood Walkability				
Low (<3.2 points)	1.09 (0.81, 1.47)	1.02 (0.92, 1.12)	1.44 (0.98, 2.11)	1.30 (0.86, 1.96)
High (>=3.2 points)	0.82 (0.63, 1.08)	1.00 (0.91, 1.10)	1.28 (0.94, 1.75)	1.03 (0.75, 1.41)

* $p < 0.1$.
** $p < 0.05$.

possible explanation may be that the intervention which provided personalised advice, was tailored well for participants of all ages. Our previous study has reported similar findings that computer-tailored intervention tailored well for both younger and older participants (Vandelanotte and De Bourdeaudhuij, 2003).

Neighbourhood environment related factors have been found to moderate effects of interventions (Perez et al., 2017; Gebel et al., 2011; Kerr et al., 2010). One study found participants in the intervention group increased their physical activity more when they rated their neighbourhood aesthetic favourably (Perez et al., 2017; Gebel et al., 2011). However, another study found that overweight men increased their walking time more if the environment they lived in was less walkable (Kerr et al., 2010). In the present study, the three-way interaction was not statistically significant for neighbourhood walkability. This could also be because the intervention was tailored well to the need of those living in neighbourhood with different levels of walkability.

Studies have shown that those with lower SES represented by education level, income, and employment status may have less opportunities to participate in physical activity and therefore may benefit more from an intervention with personalised information on how to become and stay more active (Luten et al., 2016; Yildirim et al., 2011; van Stralen et al., 2010). In addition, previous physical activity interventions have also shown to be more effective for people with lower baseline BMI who tend to adhere more to lifestyle interventions (Burgess et al., 2017). However, in this study, moderation effects of these factors were not found. More studies with sufficient sample sizes are needed to test the moderation effects of these factors.

Although strengths of this study include using validated tools and accelerometers to objectively measure physical activity, there are also limitations. First, the intervention was not specifically designed to test three-way interaction terms and therefore sample size was not calculated for this purpose. However, given the consistent patterns across both objective and subjective physical activity measures for some moderators, significant effects may have been detected with a larger sample. Additionally, attrition rate was high resulting in reduced power for interaction tests. High drop-out is common among web-based interventions (Vandelanotte, 2018; Eysenbach, 2005; Van der Mispel et al., 2017). The lack of face-to-face contact with the research team may have decreased the sense of accountability in participants, making it easier for them to drop-out, as was also reported in other web-based interventions (Vandelanotte, 2018; Duncan et al., 2014). The high burden of completing the lengthy telephone-administered questionnaires at different time points may also have contributed to the large drop-out (Walthouwer et al., 2015). Further, randomisation was not completely successful. Although most of sample characteristics were similar between the two groups, BMI was different between the two groups. Baseline physical activity measures were also not similar for subgroups. For example, men in the intervention group had higher accelerometer measured physical activity levels compared to those in the control group; and those aged <45 years had higher physical activity compared to the control group. Finally, self-reported measures despite being validated were used and therefore subject to information bias.

5. Conclusions

The intervention appeared to be more effective for women compared to men. No significant three-way interactions were found for the other potential moderators. Strategies to improve levels of personalisation may be needed so that physical activity interventions can fit better to

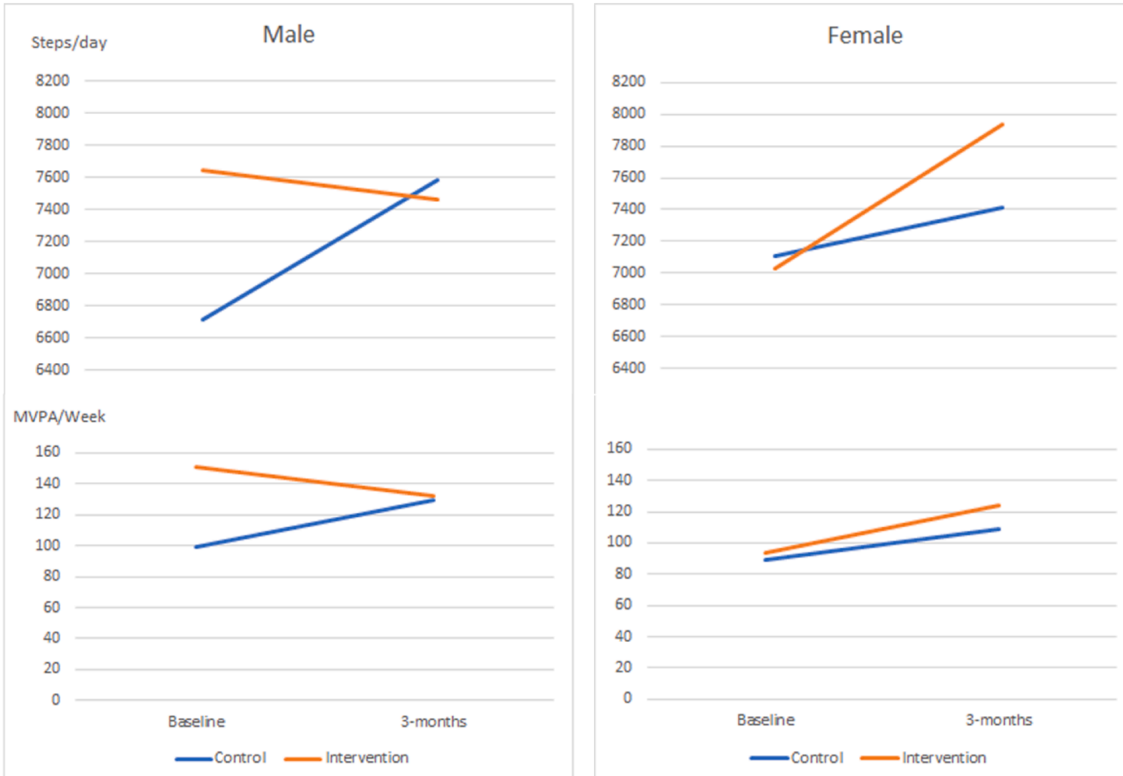

Fig. 1. Steps/day and Minutes of MVPA/Week by group for male and female.

individuals across multiple moderators (especially sex) and therefore improve intervention effectiveness. Also, more research should examine moderation effects to confirm these findings.

Authors contributions

All authors significantly contributed to the manuscript. CV, CES, RCP, WKM and MJD conceived the project and procured the project funding. CV led the coordination of the trial. CV, CES, RCP, AR, SJA, SS, WKM and MJD assisted with the protocol design. QT did the analysis and drafted the manuscript. QT, MJD, CV interpreted the data. All authors read, edited, and approved the final manuscript.

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Ethical approval

Ethical approval for the TaylorActive trial was granted by the Human Research Ethics Committee of the Central Queensland University (reference number: H14/07-163). All participants provided consent to participate.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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