Mental Health and Physical Activity 25 (2023) 100560

Contents lists available at ScienceDirect

Mental Health and Physical Activity

journal homepage: www.elsevier.com/locate/menpa

Investigating psychosocial and behavioural mediators of the relationship between physical activity and depressive symptoms in women from socioeconomically disadvantaged neighbourhoods

Thea Baker [a,*], Rhiannon White [b], Gavin Abbott [a], Eloise Litterbach [a], Megan Teychenne [a]

[a] Deakin Univeristy, Institute for Physical Activity and Nutrition (IPAN), School of Exercise and Nutrition Sciences, Geelong, Australia
[b] School of Health Sciences, Western Sydney University, Penrith, NSW, Australia

1. Introduction

Depression is considered one of the most significant burdens on health care systems across the world and is the most prevalent cause of disease-related disability in women (Ekkekakis, 2013; Greden, 2001; Noble, 2005). The heterogeneity of depression and its breadth of symptomology poses significant challenges for traditional treatment approaches, which include pharmacotherapy and psychotherapy either in isolation or combined (Kandola et al., 2019). Traditional treatment approaches come with a range of challenges for both healthcare practitioners and individuals in need of support. These include the social stigma associated with mental health, side-effects of existing pharmacological treatments, availability, and barriers to access (e.g., cost), and compliance to psychotherapeutic interventions (Ekkekakis, 2013; Kandola et al., 2019). Further, women are almost twice as likely as men to be diagnosed with depression, which presents additional complexities and considerations when seeking effective treatments of depression for this cohort (Leach et al., 2008; Noble, 2005). Reasons for this large gender disparity may include women experiencing unequal distribution of socioeconomic resources. On average, women are likely to earn less, have less consistent and stable employment throughout their lives, and have lower education levels when compared to men, which are indicators of socioeconomic disadvantage associated with higher rates of depression (Allahverdipour et al., 2021; Leach et al., 2008).

It is well established that physical activity can support both the treatment and prevention of depressive symptoms, in addition to improving the mental and physical wellbeing of those in the general population, and those with clinical depression (Fox, 1999; Peddie et al., 2020). However, the domain (i.e., life context) of physical activity appears to play a key role in physical activity's buffering effect on depression (Kull et al., 2012; White et al., 2017). Leisure-time, and in some cases transport-related physical activity, appears to be the most protective when it comes to depressive symptoms; conversely occupational physical activity has been shown to be a risk factor for poorer mental health outcomes in some studies (White et al., 2017). However, the reasons for these differing associations between each physical activity domain and mental health outcomes (such as depression) are not well understood. One suggestion from existing literature suggests that psychosocial factors (such as enjoyment and autonomy) may be responsible, and these factors may be more pronounced in leisure-time and transport-related domains, compared to occupational or domestic physical activity (Teychenne et al., 2020).

Whilst there has been considerable research into the efficacy of physical activity for the treatment and prevention of depression, there remains a paucity of research into the specific mechanisms through which they operate and provide anti-depressant effects (Fox, 1999; Kandola et al., 2019; Lubans et al., 2016; Paluska & Schwenk, 2000). Understanding the mechanisms that may explain the relationship between physical activity and depression is crucial for informing the appropriate design and development of physical activity interventions to enhance mental health (Cerin, 2010). The mechanisms that mediate the relationship between physical activity and depression are broadly understood to fall into four different categories; 1) neurobiological (e.g., neuroplasticity, oxidative stress); 2) psychosocial (e.g., self-efficacy, coping skills); 3) behavioural (e.g., sleep, sedentary activities); and 4) physiological (e.g., thermogenesis, mitochondrial morphology), which have been conceptualised by a number of existing frameworks (Fox, 1999; Kandola et al., 2019; Lubans et al., 2016; Paluska & Schwenk, 2000). Yet, psychosocial and behavioural mechanisms have been poorly researched to date (Cerin, 2010), despite these factors being more easily manipulated in the design of population-based physical activity interventions to enhance mental health. Robust mediation studies that identify the mechanisms explaining the physical activity – depression relationship, and the eventual causal relationships, necessitate statistical

* Corresponding author. School of Exercise and Nutrition Sciences, Deakin University 221 Burwood Hwy, Burwood, VIC, 3125, Australia.
E-mail addresses: thea.baker@deakin.edu.au (T. Baker), rhiannon.white@westernsydney.edu.au (R. White), gavin.abbott@deakin.edu.au (G. Abbott), elitterbach@deakin.edu.au (E. Litterbach), mteych@deakin.edu.au (M. Teychenne).

https://doi.org/10.1016/j.mhpa.2023.100560
Received 16 May 2023; Received in revised form 27 September 2023; Accepted 26 October 2023
Available online 29 October 2023

mediation analyses. This refers to statistical procedures that test the hypothesis that an independent variable (X) affects an outcome (Y) through one or more mediators (M) (Cerin, 2010). However, of the few existing mediation studies amongst women ($n = 4$), a narrow range of possible mediators were addressed including self-efficacy, self-esteem, the social context of physical activity, mindfulness, and rumination. There were no studies that explored behavioural mechanisms as mediators between physical activity and depression symptoms in women (Chu et al., 2009; Craft, 2005; La Rocque et al., 2021; Ryan, 2008). Further, the mediation studies to date have assessed only leisure-time physical activity (Chu et al., 2009; Craft, 2005; La Rocque et al., 2021; Ryan, 2008) despite it now being understood that different domains of physical activity can have different (and in some cases, completely opposing) effects on mental health (Vella et al., 2023).

To date there have been numerous hypotheses suggested explaining the relationship between physical activity and mental health (e.g., depressive symptoms). However, the underlying mechanisms (i.e., mediators) explaining the relationship are likely to differ according to the life domain in which physical activity is undertaken (White et al., 2017). For example, leisure-time and transport-related physical activity might provide a **distraction** from life's stressors, whilst undertaking high levels of physical activity at work might not provide the same mental health buffer (Leith, 2010; White et al., 2017). Engaging in physical activity with others (i.e., the **social interaction** hypothesis) might also enhance the positive effect of leisure-time physical activity on mental health, yet domestic physical activity (i.e., household chores) is usually conducted alone (Bailey & McLaren, 2005). While leisure-time physical activity is an ideal domain to understand mediation effects since it is most likely to lead to lower levels of depressive symptoms, women engage in high levels of physical activity across other domains of physical activity, including transport-related, occupational, household and child-rearing activities (Ainsworth et al., 1999; Kull et al., 2012). Therefore, the current study sought to investigate the psychosocial and behavioural mediators of the relationship between the different PA domains (specifically leisure-time, transport-related, occupational, domestic) and depressive symptoms in community-dwelling adult women from socioeconomically disadvantaged neighbourhoods in Victoria, Australia.

2. Methods

This prospective study involved secondary analysis of self-reported survey data originally collected across two time points, in 2007/2008 and 2010/11 as part of the longitudinal study Resilience for Eating and Activity Despite Inequality (READI) Study (Ball et al., 2013).

2.1. Participants and procedure

Participants were women (aged 18-45) living in socioeconomically disadvantaged neighbourhoods in Victoria, Australia (Ball et al., 2013). Specifically, women were recruited from 80 (40 urban: 40 rural) socioeconomically disadvantaged neighbourhoods in Victoria based on being classified in the lowest tertile of the Index of Relative Socio-economic Disadvantage (SEIFA) (Australian Bureau of Statistics, 2018). The electoral roll was then utilised to randomly select 150 women from each of the 80 selected neighbourhoods, resulting in a final sampling pool of 11940 women.

A pre-survey letter was sent to these 11940 eligible women and the survey itself sent one week later. Following the Dillman approach (Dillman, 1982), reminder letters were sent 10 days following the original survey. Of the original 11940 surveys, $n = 861$ (7.2%) were undeliverable. A total of 4938 completed surveys were received (response rate of 45%). Women were excluded from the study for the following reasons: women who had moved out of the surveyed neighbourhoods ($n = 571$), those who were the unintended recipient ($n = 3$), who withdrew consent to be involved ($n = 2$) and were outside of the age range <17 or >46 years ($n = 13$). This resulted in 4349 (39% of those delivered a survey) eligible women at survey baseline (T1) (See Fig. 1). Three years after baseline, a follow-up survey was sent out (T2: 2010/2011) to eligible women who had provided consent to be involved in future studies ($n = 3019$). At T2 1912 surveys (63% of eligible participants) were completed.

2.2. Ethics

The READI study was approved by the Deakin University Research Ethics Committee (HEAG-H 91_2006). All participants provided written consent to participate. Exemption of ethics for this research project (involving secondary data analysis) was approved by Deakin University Human Research Ethics Committee on 9th June 2022.

2.3. Measures

2.3.1. Predictor variable: Physical activity

Physical activity was measured using the long-form version of the International Physical Activity Questionnaire (IPAQ-L), a valid and reliable measure involving a seven-day recall of physical activity behaviours (Craig et al., 2003). Participants were asked to self-report their physical activity over the previous week across four domains: occupation, transport-related, leisure-time and domestic. For each domain participants were asked to estimate the number of days, hours, and minutes they had spent engaged in such walking, moderate- and vigorous-intensity activities in the preceding week. Across all physical activity domains, time (frequency x duration) spent in each intensity (walking, vigorous and moderate) were summed to calculate the total weekly time (minutes) spent being active within each domain. Data were truncated as per existing protocols to remove unrealistic data values.

2.3.2. Outcome variable: Depressive symptoms

Participants were asked to self-report depressive symptoms over the previous week using the 10-item version of the Centre for Epidemiologic Studies Depression Scale (CES-D 10) a well-validated measure of depressive symptoms (Andresen et al., 1994; Radloff, 1977). For each item (i.e., symptom) participants rated themselves on a 4-point scale of severity (0 = rarely or none of the time; to 3 = most or all the time). Responses were then summed across the 10 items to give a total score (possible range: 0–30). Participants were categorised as either 'at risk of depression' (CES-D 10 score = 10 or more) or 'not at risk of depression' (CES-D 10 score = less than 10) (Andresen et al., 1994). Depression scores were dichotomized using standard clinical cut-offs (Andresen et al., 1994) and in this form were only used to present descriptive analysis of the participants included in this study (see Table 2). For all mediation analyses CES-D 10 scores were treated as continuous.

2.4. Mediators

Nine possible psychosocial and behavioural mediating variables were explored. Psychosocial factors included: behavioural skills, social context of physical activity, behavioural intentions, outcome expectancies, enjoyment of physical activity and self-efficacy. Behavioural factors included: dietary intake of fruit and vegetables, sitting time and screen time. Details of these measures (i.e., questionnaire and survey items) are presented in Table 1. All items explored as part of the Resilience for Eating Despite Inequality (READI) study were taken from previously developed and reliable measures (Giles-Corti & Donovan, 2003; Kendzierski & DeCarlo, 1992; Lechner et al., 2006; Marcus et al., 1992; Marks et al., 2001; Salmon et al., 2003). Where variables had more than one item (e.g., enjoyment of physical activity), items were summed to calculate a total score for that variable. All variables were treated as continuous.

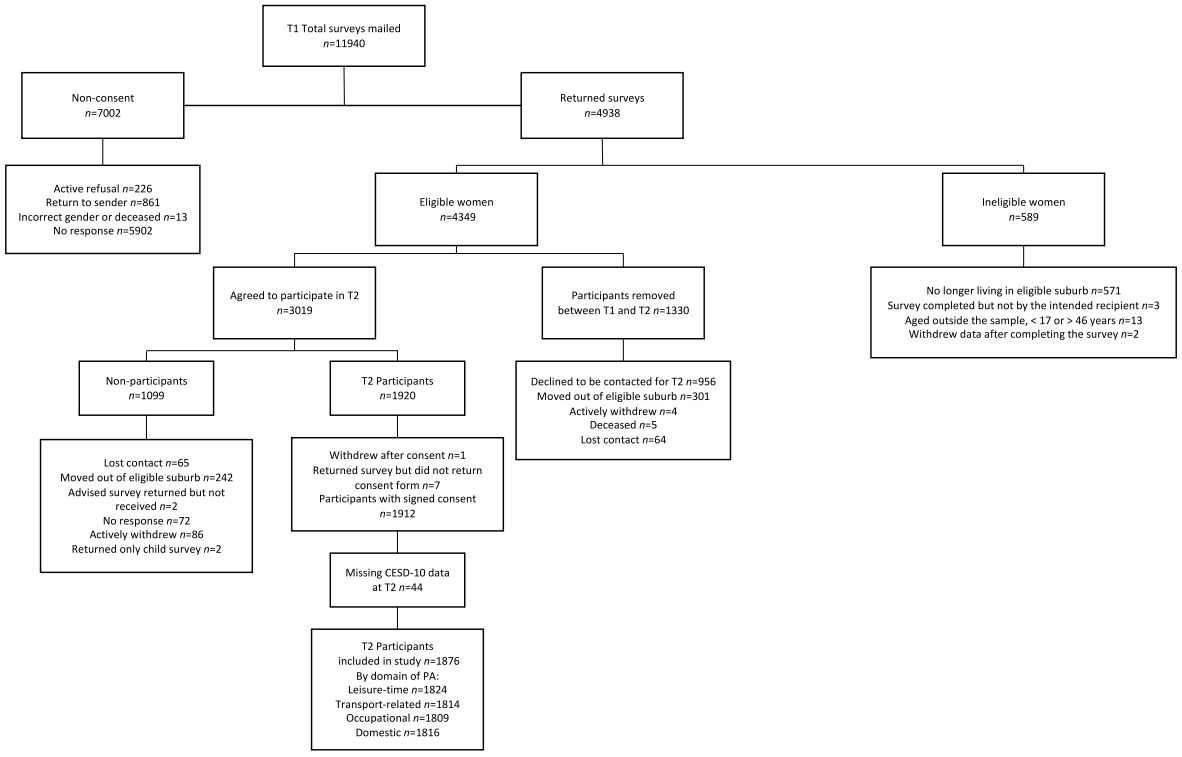


Fig. 1. Summary of women participants in the Resilience for Eating and Activity Despite Inequality (READI) study (T1: 2007/2008, T2: 2010/2011) and those included in final sample.

2.5. Covariates

The identification of potentially confounding factors was based on evidence of being theoretically associated with both physical activity and depressive symptoms (Brown & Harris, 1978; Craig & Van Natta, 1979). Covariates included baseline measures of self-reported age, body mass index (BMI), marital status, education, employment status, children living at home, country at birth and depressive symptoms (i.e., T1 CES-D 10 score), and were adjusted for in all mediation analyses.

2.6. Statistical analyses

Data for this study was analysed using STATA version 17 and statistical significance for all analyses was set at $p < .05$. Women who had missing data for the CES-D 10 at T2 were excluded from all analyses including baseline descriptive statistics ($n = 44$). Additionally, for analyses examining work-related physical activity as a predictor variable, women who reported not working or had data missing for this variable were also excluded ($n = 574$).

Descriptive analyses were used to examine the distributions of demographic characteristics (T1), physical activity across four domains (i.e., leisure-time, transport-related, occupational, domestic), depressive symptoms and potential mediating variables at T1 and T2. Linear models were used to estimate the contribution of mediators explaining the relationship between physical activity at T1 and continuous depressive symptom scores at T2, controlling for covariates in addition to clustering by neighbourhood of residence. Separate models were run for each domain of physical activity. See hypothesised mediation model (Fig. 2).

Initially, linear regression models were used to estimate overall associations between each physical activity exposure and the depressive symptoms outcome (adjusting for covariates). Next, single mediator models were fitted for each exposure/mediator pair (i.e., 36 individual models accounting for each of the possible nine mediators for within each domain of physical activity). Path analysis was used to simultaneously fit linear regression models to estimate the *a* paths (association between PA [exposure] and potential mediator), *b* paths (association between potential mediator and depressive symptoms [outcome], while adjusting for PA), and *c* paths (association between PA and depressive symptom not explained by the potential mediator[s], also known as the *direct effect*) (Imai et al., 2010).

In line with the causal inference approach to mediation analysis, *b* path models initially included the interactions of exposure and potential mediator to allow that associations between mediators and the outcome might potentially vary according to level of the exposure variable (Valeri & Vanderweele, 2013). If the exposure-moderator interaction was non-significant ($p > .05$), the interaction term was removed from the model, and subsequently mediating (indirect) effects were calculated as the product of the *a* and *b* paths. Alternatively, where there was evidence of an exposure-moderator interaction at the $p < .05$ level the interaction term was retained and natural indirect effect (NIE) and controlled direct effect (CDE) were calculated. Separate *b* paths were calculated for the exposure at +1 and −1 standard deviation, indicating the estimated associations between mediator and outcome when the exposure is either one standard deviation below or above the sample mean. Following this, two separate NIEs ($NIE_{[1]}$ & $NIE_{[2]}$) were produced. The first, $NIE_{[1]}$, estimates how much the outcome would change on average if the exposure were controlled at its mean value, but the mediator changed from the level it would take if the exposure was one standard deviation below the mean to the level it would take if the exposure was at its mean (Valeri & Vanderweele, 2013). In contrast, $NIE_{[2]}$ estimates how much the outcome would change on average if the exposure were controlled at one standard deviation above its mean, but the mediator changed from the level it would take if the exposure was at its mean to the level it would take if the exposure was one standard deviation above its mean (Valeri & Vanderweele, 2013). The CDE estimates how much the outcome would change on average if the mediator were controlled at its mean, but the exposure increased by one standard deviation.

All reported associations and path coefficients were standardised due to the different scaling for all the variables involved. Bootstrapping

Table 1
Survey items used to examine potential psychosocial and behavioural mediators from the Resilience for Eating and Activity Despite Inequality (READI) study.

Variable	Likert scale/response options	Items	Internal consistency (α)	Questions used to assess variable
Psychosocial				
Behavioural skills (Giles-Corti & Donovan, 2003)	4-point: 1 (never), 2 (once or twice), 3 (weekly), 4 (more than once/week).	Sum two items Possible score range 2–8	0.83	How many times in the past month did you: 'Set a goal for how much physical activity you would like to do?', 'Plan particular days on which you would do physical activity?'
Social context of physical activity (Giles-Corti & Donovan, 2003)	4-point: 1 (never), 2 (once or twice), 3 (weekly), 4 (more than once/week).	Single item Possible score range 1–4	N/A	How many times in the past month did you: 'Meet someone to do physical activity with?'
Behavioural intentions (Giles-Corti & Donovan, 2003)	7-point: 1 (very unlikely), 7 (very likely).	Single item Possible score range 1–7	N/A	Assuming that you tried to do physical activity over the next two weeks, how likely or unlikely is it that you would actually stick to this?
Outcome expectancies Lechner et al., 2006)	4-point: 1 (no reason at all), 4 (very important reason).	Sum six items Possible score range 6–24	0.79	How important to do think these reasons are for being physically active? 'Health', 'Appearance', 'Weight', 'Feeling fit', 'Relaxation', 'Stress relief'
Enjoyment of physical activity (Kendzierski & DeCarlo, 1991)	7-point: 1 (lease enjoyable), 7 (most enjoyable).	Sum six items Possible score range 6–42	0.95	Feelings about physical activity: 'I love it/hate it', 'I feel interested/I feel bored', 'I find it pleasurable/I find it unpleasurable', 'I find it energising/I find it tiring', 'It makes me happy/it makes me depressed', 'I feel good physically while doing it/I feel bad physically while doing it'
Self-efficacy (Marcus et al., 1992)	5-point: 1 (strongly agree), 5 (strongly disagree).	Sum five items Possible score range 5–25	0.82	I am confident that I could do physical activity even when: 'I am tired', 'I feel I don't have time', 'I am on holiday', 'It is raining'.
Behavioural				
Dietary intake of fruit and vegetables (Marks et al., 2001; Murphy et al., 2021)	8-point: 'I don't eat fruit [vegetables]', less than one serve/day, 1 serve/day, 2 serves/day, 3 serves/day, 4 serves/day, 5 serves/day, 6 serves or more/day	Sum two items Possible score range 0–12	N/A	About how many serves of fruit do you usually eat per day? Do not include fruit juice, About how many serves of vegetables do you usually eat per day? Do not include potatoes, hot chips or fried potato.
	Method of assessment	**Items**		**Questions used to assess variable**
Sitting time (Salmon et al., 2003)	Assessed using IPAQ-L	Possible range 0–7560 (mins)	N/A	Estimate number of hours and minutes spent sitting on a weekday as well as weekend day.
Screen time ((Salmon et al., 2003)	Assessed using established self-report measures of TV and computer use	Possible range 0–7560 (mins)	N/A	Estimate number of hours and minutes spent watching television and sitting at a computer on a weekday as well as a weekend day.

Note: α = Cronbach's alpha, N/A = non-applicable.

(1000 replications) was used to produce percentile-based confidence intervals (CIs) of the indirect effects, (Hayes & Scharkow, 2013). Percentile bootstrap CIs are asymmetrical, therefore exact *p*-values are not calculated; however, a 95% CI of the indirect effect that did not cross zero was considered to show a statistically significant indirect effect at the $p < .05$ level. Multiple mediator analyses were subsequently conducted for any domain of physical activity where there was more than one potential mediator with a statistically significant indirect effect following single mediation analyses.

3. Results

3.1. Sociodemographic characteristics

Table 2 presents the sociodemographic characteristics of participants included in this study at baseline. The included sample of women (n = 1876) were a mean age of 36 years old (±7.7 years). About half the participants had completed high school or equivalent (49.9%). Most were in married/*de facto* relationships (71.6%), were employed in either a full-time or part-time capacity (69.9%), were born in Australia (92.5%), and had one or more children (64.6%). At baseline, 33% of the participants were considered at risk of depression (i.e., had a CES-D 10 score of more than 10). Descriptive characteristics of physical activity by domain for women in the sample at T1 and T2 are shown in Table 3.

Overall, leisure-time physical activity (β = 0.011 p = .59 95% CI -0.029, 0.051), transport-related physical activity (β = 0.026 p = .19 95% CI -0.013, 0.066), occupational physical activity (β = 0.007 p = .74 95% CI -0.034, 0.048), and domestic physical activity (β = 0.038 p = .071 95% CI -0.003, 0.078) were not significantly associated with depression at follow-up (T2). Table 4 presents results for single mediation analysis including *a* path, *b* path, direct (*c* path) and bootstrapped indirect effects (*ab* path) for all psychosocial and behavioural factors hypothesised to mediate the relationship between PA across four domains (i.e., leisure-time, transport-related, occupational, and domestic) and depressive symptoms.

Leisure-time physical activity was significantly positively associated with all the potential psychosocial mediators as well as with dietary intake of fruit and vegetables. Enjoyment of physical activity (β = −.016 95% CI -0.030, −0.001), self-efficacy (β = −0.018 95% CI -0.033, −0.003) and behavioural intentions (β = −0.012 95% CI -0.024, −0.0002) were significant mediators of the relationship between leisure-time physical activity and depressive symptoms. Multiple mediation analyses were performed by entering only the hypothesised mediators that were found to significantly contribute to mediating the association between leisure-time physical activity and depressive symptoms in single mediation analyses (i.e., enjoyment of physical activity, self-efficacy, and behavioural intentions). Within this model none of the potential psychosocial factors remained significant mediators in the full model (see Table 4).

Transport-related physical activity was significantly positively associated with enjoyment of physical activity, self-efficacy and with dietary intake of fruit and vegetables and was inversely associated with sitting and screen time. Enjoyment of physical activity (β = −.003 95% CI -0.008, −0.000) and one of the NIE pathways for self-efficacy ($NIE_{[2]}$ β = −0.011 CI -0.020, −0.004) (i.e., where transport-related physical activity was controlled at one standard deviation above its mean, but

Table 2
Sociodemographic characteristics of women in the Resilience for Eating and Activity Despite Inequality (READI) study (final included sample) at baseline (2007/2008).

Baseline participant characteristics (n = 1876)	Mean (SD)
Age	36.0 (7.7)
Body Mass Index (BMI)	26.2 (6.0)
	n (%)
Body Mass Index (BMI)	
Not overweight	934 (52.0)
Overweight	474 (26.4)
Obese	389 (21.6)
Marital status	
Married/*de facto*	1346 (71.6)
Separated/divorced/widowed	152 (8.1)
Never married	381 (20.2)
Employment status	
Working full-time	685 (37.0)
Working part-time	608 (32.9)
Not currently employed in paid work	557 (30.1)
Country of birth	
Australia	1739 (92.5)
Other	142 (7.6)
Number of children (up to 18 yrs)	
None	661 (35.5)
One	349 (18.8)
Two	506 (27.2)
Three or more	345 (18.6)
Education	
Low (did not complete high school)	405 (21.6)
Medium (completed high school or equivalent)	934 (49.9)
High (completed tertiary education)	533 (28.5)
Depressive symptoms (CES-D 10)	
At risk of depression (CES-D 10 score ≥10)	617 (33.0)
Not at risk of depression (CES-D 10 score ≤10)	1251 (67.0)

self-efficacy changed from the level it would take if transport-related physical activity was at its mean to the level it would take if transport-related physical activity was one standard deviation above its mean) were significant mediators of the relationship between transport-related physical activity and depressive symptoms. Multiple mediation analyses were also performed by entering only the hypothesised mediators that were found to be significantly associated with transport-related physical activity and depressive symptoms in single mediation analyses (i.e., enjoyment of physical activity and self-efficacy). The same NIE pathway ($NIE_{[2]}$) for self-efficacy as in the single mediation model remained as a significant mediator of the relationship between transport-related physical activity and depressive symptoms ($NIE_{[2]}$ β = −0.010 CI -0.020, −0.003) in the full model whilst enjoyment of physical activity did not (see Table 5).

Occupational physical activity was significantly positively associated with self-efficacy, and inversely associated with behavioural skills, social context of physical activity, sitting time and screen time. Of the potential mediators, only self-efficacy mediated the relationship between occupational physical activity and depressive symptoms (β = −.008 95% CI -0.016, −0.002).

Domestic physical activity was significantly positively associated with self-efficacy and with dietary intake of fruit and vegetables but was significantly, and inversely associated with social context of physical activity, sitting time and screen time. Self-efficacy mediated the relationship between domestic physical activity and depressive symptoms (β = −.004 95% CI -0.009, −0.0002).

4. Discussion

The findings of the current study provide evidence for the effect of specific domains of PA (leisure-time and transport-related) and mediators (enjoyment of physical activity, self-efficacy, behavioural intentions) to predict future depression over and above baseline depression. Further, these findings are consistent with findings in previous studies whereby leisure-time and transport-related physical activity was strongly inversely associated with depressive symptoms (Chu et al., 2009; Craft, 2005; La Rocque et al., 2021; Ryan, 2008; Teychenne et al., 2008b). Such evidence provides further motivation to understand

Table 3
Descriptive characteristics (mean and standard deviation) of physical activity by domain of physical activity and depressive symptoms (CES-D 10) of women in the Resilience for Eating and Activity Despite Inequality (READI) study (T1: 2007/2008, T2: 2010/2011).

Domain of physical activity	T1		T2	
	Mean	SD	Mean	SD
Occupational PA[a] (hrs/wk)	10.1	13.7	8.2	12.4
Transport-related PA (hrs/wk)	2.8	4.2	2.6	4.1
Domestic PA (hrs/wk)	10.8	11.2	10.1	11.0
Leisure-time PA (hrs/wk)	3.5	4.8	3.5	4.4
Depressive symptoms	**T1**		**T2**	
	Mean	*SD*	*Mean*	*SD*
CES-D 10	8.34	5.5	7.9	5.7

[a] *Only women who were employed at T1(2007/2008) (n = 1235) PA = physical activity.*

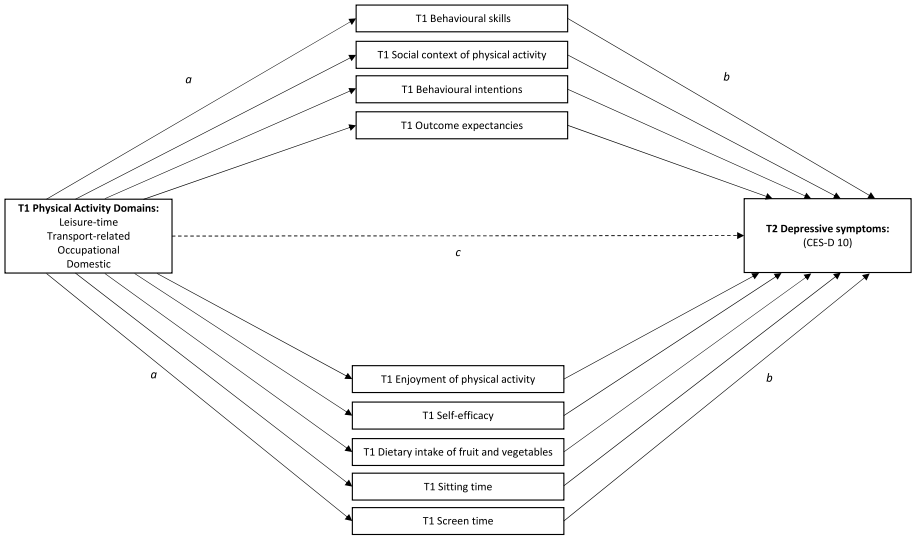


Fig. 2. Hypothesised mediation model.

Table 4
Results for single mediation analyses including a path, b path, direct (c path) and bootstrapped indirect effects (ab path).

Mediator	a (effect of PA exposure on mediator)		b (effect of mediator on depressive symptoms outcome) [a]		*c* (direct effect) [b]		*ab* (indirect effect) [c]
	B (95% CI)	*p-value*	B (95% CI)	*p-value*	B (95% CI)	*p-value*	B (95% CI)
Leisure-time physical activity							
Enjoyment of PA	**0.291 (0.254, 0.329)**	**<.001**	**−0.053 (-0.099, -0.008)**	**.021**	0.029 (−0.013, 0.070)	.18	**−0.016 (-0.030, -0.001)**
Self-efficacy	**0.315 (0.270, 0.359)**	**<.001**	**−0.057 (-0.105, -0.010)**	**.019**	0.027 (−0.014, 0.068)	.19	**−0.018 (-0.033, -0.003)**
Outcome expectancies	**0.148 (0.098, 0.198)**	**<.001**	−0.015 (−0.051, 0.021)	.42	0.013 (−0.027, 0.052)	.54	−0.002 (−0.008, 0.004)
Behavioural intentions	**0.258 (0.211, 0.305)**	**<.001**	−0.045 (−0.091, 0.001)	.055	0.023 (−0.016, 0.062)	.25	**−0.012 (-0.024, -0.0002)**
Behavioural skills	**0.292 (0.243, 0.342)**	**<.001**	0.178 (−0.017, 0.052)	.32	0.005 (−0.036, 0.045)	.81	0.005 (−0.007, 0.016)
Social context of PA	**0.253 (0.203, 0.303)**	**<.001**	−0.031 (−0.072, 0.010)	.14	0.020 (−0.021, 0.061)	.34	−0.008 (−0.018, 0.002)
Dietary intake fruit & veg	**0.149 (0.098, 0.200)**	**<.001**	−0.049 (−0.105, 0.007)	.086	−0.009 (−0.049, 0.032)	.67	−0.007 (−0.018, 0.002)
			0.050 (−0.006, 0.107)	.080			0.008 (−0.001, 0.017)
Sitting time	−0.039 (−0.086, 0.008)	.10	−0.012 (−0.057, 0.032)	.58	0.012 (−0.028, 0.052)	.56	0.001 (−0.001, 0.003)
Screen time	0.005 (−0.039, 0.051)	.81	0.012 (−0.029, 0.052)	.58	0.013 (−0.030, 0.056)	.54	0.000 (−0.001, 0.002)
Transport-related physical activity							
Enjoyment of PA	**0.064 (0.019, 0.110)**	**.005**	**−0.051 (-0.096, -0.006)**	**.026**	0.036 (−0.004, 0.076)	.077	**−0.003 (-0.008, -0.0001)**
Self-efficacy	**0.104 (0.055, 0.154)**	**<.001**	−0.020 (−0.069, 0.029)	.42	0.039 (−0.0004, 0.079)	0.053	−0.002 (−0.008, 0.004)
			−0.104 (-0.174, -0.035)	**.003**			**−0.011 (-0.020, -0.004)**
Outcome expectancies	0.033 (−0.018, 0.084)	.20	−0.005 (−0.042, 0.033)	.80	0.032 (−0.008, 0.072)	.12	−0.000 (−0.002, 0.002)
Behavioural intentions	0.022 (−0.032, 0.076)	.42	−0.037 (−0.085, 0.010)	.12	0.032 (−0.008, 0.072)	.12	−0.001 (−0.004, 0.001)
Behavioural skills	0.040 (−0.010, 0.091)	.12	0.027 (−0.006, 0.059)	.11	0.031 (−0.009, 0.071)	.13	0.001 (−0.001, 0.004)
Social context of PA	0.036 (−0.007, 0.080)	.10	−0.027 (−0.066, 0.012)	.18	0.031 (−0.006, 0.073)	.099	−0.001 (−0.004, 0.001)
Dietary intake fruit & veg	**0.058 (0.006, 0.111)**	**.028**	0.005 (−0.036, 0.045)	.82	0.031 (−0.008, 0.071)	.12	−0.000 (−0.002, 0.004)
Sitting time	**−0.067 (-0.118, -0.016)**	**.011**	−0.011 (−0.056, 0.034)	.64	0.036 (−0.005, 0.077)	.085	−0.001 (−0.003, 0.004)
Screen time	**−0.058 (-0.103, -0.014)**	**.010**	0.017 (−0.023, 0.058)	.41	0.029 (−0.012, 0.070)	.17	−0.001 (−0.004, 0.002)
Mediator	*a (effect of independent variable on mediator)*		*b (effect of mediator on dependent variable)* [a]		*c* (direct effect) [b]		*ab* (indirect effect) [c]
	B (95% CI)	*p-value*	B (95% CI)	*p-value*	B (95% CI)	*p-value*	B (95% CI)
Occupational physical activity							
Enjoyment of PA	−0.004 (−0.065, 0.056)	.89	**−0.066 (-0.121, -0.011)**	**.018**	−0.017 (−0.071, 0.036)	.53	0.000 (−0.004, 0.005)
Self-efficacy	**0.089 (0.031, 0.146)**	**.003**	**−0.091 (-0.142, -0.039)**	**.001**	−0.010 (−0.064, 0.044)	.71	**−0.008 (-0.016, -0.002)**
Outcome expectancies	−0.049 (−0.111, 0.013)	.12	0.021 (−0.026, 0.070)	.38	−0.017 (−0.071, 0.038)	.55	−0.001, (−0.005, 0.002)
Behavioural intentions	−0.038 (−0.094, 0.018)	.18	−0.049 (−0.111, 0.013)	.12	−0.019 (−0.073, 0.035)	.49	0.002 (−0.001, 0.007)
Behavioural skills	**−0.088 (-0.148, -0.027)**	**.005**	0.023 (−0.022, 0.068)	.32	−0.016 (−0.070, 0.039)	.58	−0.002 (−0.008, 0.003)
Social context of PA	**−0.076 (-0.133, -0.019)**	**.010**	−0.041 (−0.091, 0.009)	.10	−0.022 (−0.077, 0.032)	.43	0.003 (−0.001, 0.008)
Dietary intake fruit & veg	0.019 (−0.041, 0.079)	.54	−0.008 (−0.058, 0.042)	.76	−0.017 (−0.072, 0.037)	.53	−0.000 (−0.002, 0.002)
Sitting time	**−0.214 (-0.282, -0.146)**	**<.001**	−0.027 (−0.082, 0.029)	.35	−0.020 (−0.076, 0.037)	.50	0.006 (−0.006, 0.018)
Screen time	**−0.190 (-0.260, -0.119)**	**<.001**	0.006 (−0.043, 0.055)	.81	−0.017 (−0.076, 0.042)	.58	−0.001 (−0.012, 0.009)
Mediator	a (effect of independent variable on mediator)		b (effect of mediator on dependent variable) [a]		*c* (direct effect) [b]		*ab* (indirect effect) [c]
	B (95% CI)	*p-value*	B (95% CI)	*p-value*	B (95% CI)	*p-value*	B (95% CI)
Domestic physical activity							
Enjoyment of PA	0.033 (−0.019, 0.085)	.22	−0.036 (−0.080, 0.008)	.11	**0.043 (0.006, 0.080)**	**.021**	−0.001 (−0.004, 0.001)
Self-efficacy	**0.081 (0.033, 0.129)**	**.001**	**−0.047 (-0.093, -0.002)**	**.040**	**0.042 (0.004, 0.080)**	**.031**	**−0.004 (-0.009, -0.0002)**
Outcome expectancies	0.045 (−0.005, 0.095)	.078	−0.011, (−0.048, 0.026)	.57	**0.039 (0.001, 0.076)**	**.046**	−0.001 (−0.003, 0.001)
Behavioural intentions	0.024 (−0.028, 0.075)	.37	−0.036 (−0.083, 0.011)	.13	**0.038 (0.0002, 0.076)**	**.049**	−0.001 (−0.004, 0.001)
Behavioural skills	−0.026 (−0.068, 0.015)	.22	0.028 (−0.004, 0.059)	.089	**0.039 (0.001, 0.077)**	**.046**	−0.001 (−0.003, 0.001)
Social context of PA	**−0.054 (-0.101, -0.007)**	**.024**	−0.024 (−0.062, 0.014)	.22	**0.038 (0.0002, 0.076)**	**.049**	0.001 (−0.001, 0.004)
Dietary intake fruit & veg	**0.062 (0.019, 0.105)**	**.005**	−0.003 (0.039, 0.045)	.89	**0.038 (0.0004, 0.075)**	**.048**	0.000 (−0.002, 0.003)
Sitting time	**−0.098 (-0.146, -0.050)**	**<.001**	−0.016 (−0.054, 0.031)	.59	0.034 (−0.008, 0.075)	.11	0.001 (−0.003, 0.006)
Screen time	**−0.062 (-0.105, -0.019)**	**.004**	**0.062 (0.010, 0.114)**	**.020**	**0.046 (0.004, 0.087)**	**.030**	−0.004 (−0.009, 0.0001)
			−0.034 (−0.095, 0.027)	.28			0.002 (−0.003, 0.008)

Note: Bootstrap resamples = 1000. For ease of interpretation, results shown to four decimal places where first three decimal places are zero. Standardised coefficients presented. All analyses adjusted for age, BMI, marital status, education, employment status, number of children living at home under 18 years, country of birth and baseline depression symptoms and clustering by neighbourhood. *CI = confidence interval. PA = physical activity.*

[a] Where there was evidence of an exposure moderator interaction at the $p < .05$ level the interaction term was retained, and natural indirect effect (NIE) was calculated. Separate b paths were calculated for the exposure at +1 and −1 standard deviation. This was used to calculate separate NIE paths where $NIE_{[1]}$, estimates how much the outcome would change on average if the exposure were controlled at its mean value, but the mediator changed from the level it would take if the exposure was one standard deviation below the mean to the level it would take if the exposure was at its mean. In contrast, $NIE_{[2]}$ estimates how much the outcome would change on average if the exposure were controlled at one standard deviation above its mean, but the mediator changed from the level it would take if the exposure was at its mean to the level it would take if the exposure was one standard deviation above its mean.

[b] Where there was evidence of an exposure moderator interaction at the $p < .05$ level the interaction term was retained, and the controlled direct effect (CDE) was calculated. The CDE estimates how much the outcome would change on average if the mediator were controlled at its mean, but the exposure increased by one standard deviation.

[c] Where there was evidence of an exposure moderator interaction at the $p < .05$ level the interaction term was retained, and two indirect effect paths were calculated.

Table 5
Results for multiple mediation analyses including a path, b path, direct (c path) and bootstrapped indirect effects (ab path).

	a (effect of PA exposure on mediator)		b (effect of mediator on depressive symptoms outcome) [a]		*c* (direct effect) [b]		*ab* (indirect effect) [c]
Mediator	B (95% CI)	*p-value*	B (95% CI)	*p-value*	B (95% CI)	*p-value*	B (95% CI)
Leisure-time physical activity							
Enjoyment of PA	**0.295 (0.257, 0.332)**	**<.001**	−0.020 (−0.069, 0.030)	.433	0.036 (−0.005, 0.077)	.084	−0.006 (−0.022, 0.010)
Self-efficacy	**0.315 (0.269, 0.360)**	**<.001**	−0.044 (−0.095, 0.007)	.089			−0.014 (−0.032, 0.002)
Behavioural intentions	**0.258 (0.209, 0.307)**	**<.001**	−0.023 (−0.073, 0.028)	.373			−0.006 (−0.020, 0.006)
Transport-related physical activity							
Enjoyment of PA	**0.071 (0.026, 0.116)**	**.002**	−.019 (−.065, .027)	.472	**0.041 (0.001, 0.081)**	**.045**	−0.001 (−0.005, 0.003)
Self-efficacy	**0.102 (0.052, 0.152)**	**.019**	**−0.057 (-0.104, -0.009)**	**.019**			−0.001 (−0.009, 0.005)
							−0.010 (-0.020, -0.003)

Note: Bootstrap resamples = 1000. For ease of interpretation, results shown to four decimal places where first three decimal places are zero. Standardised coefficients presented. All analyses adjusted for age, BMI, marital status, education, employment status, number of children living at home under 18 years, country of birth and baseline depression symptoms and clustering by neighbourhood. *CI = confidence interval. PA = physical activity.*

[a] Where there was evidence of an exposure moderator interaction at the $p < .05$ level the interaction term was retained, and natural indirect effect (NIE) was calculated. Separate b paths were calculated for the exposure at +1 and −1 standard deviation. This was used to calculate separate NIE paths where $NIE_{[1]}$, estimates how much the outcome would change on average if the exposure were controlled at its mean value, but the mediator changed from the level it would take if the exposure was one standard deviation below the mean to the level it would take if the exposure was at its mean. In contrast, $NIE_{[2]}$ estimates how much the outcome would change on average if the exposure were controlled at one standard deviation above its mean, but the mediator changed from the level it would take if the exposure was at its mean to the level it would take if the exposure was one standard deviation above its mean.

[b] Where there was evidence of an exposure moderator interaction at the $p < .05$ level the interaction term was retained, and the controlled direct effect (CDE) was calculated. The CDE estimates how much the outcome would change on average if the mediator were controlled at its mean, but the exposure increased by one standard deviation.

[c] Where there was evidence of an exposure moderator interaction at the $p < .05$ level the interaction term was retained, and two indirect effect paths were calculated.

the underlying mechanisms that mediate these relationships (Brosse et al., 2002; Cerin; 2010; Fox, 1999; Paluska & Schwenk, 2000; Peddie et al., 2020). A major finding of this study is that the relationship between physical activity and depressive symptoms in women living in socioeconomic disadvantaged neighbourhoods was only mediated by psychosocial factors, but not by behavioural factors. Additionally, regarding psychosocial factors, only psychological factors (i.e., self-efficacy, enjoyment of physical activity and behavioural intentions), rather than social factors provided any evidence of mediation in this relationship. It is possible that other behavioural and social factors not assessed as part of this study that may mediate the physical activity – depression relationship, however, the findings of this study suggest that physical activity interventions designed to support mental health, specifically depression, should be created with consideration given to these psychological factors.

Another significant finding of the present study is that there was both some similarity and some contrast between the mediating factors across the four domains of physical activity. Self-efficacy was a significant mediator across all four domains. However, other psychosocial factors (namely enjoyment of physical activity and behavioural intentions) mediated the relationship between physical activity and depressive symptoms only within the domains of leisure-time and transport-related physical activity. These findings emphasise that the factors affecting the physical activity - depression relationship are different depending on the domain of physical activity. Understanding the broader context of physical activity is key for a deeper understanding of how to optimally prevent depression via physical activity (White et al., 2017). Higher occupational physical activity has been shown to result in lower engagement in leisure-time physical activity because of the perception that individuals have engaged in sufficient physical activity throughout the workday, however the mental health benefits that come from this type of activity are not equal to those acquired from leisure-time physical activity (Cusatis & Garbarski, 2019; White et al., 2017). Further, leisure-time and transport-related physical activity are more strongly connected to individual choice, autonomous motivation, and enjoyment. Within the domains of occupational and domestic physical activity there is likely more controlled motivation with a likely reduction in depression-buffering effect of the physical activity.

Although single mediating models showed that three factors partly mediated the relationship between leisure-time physical activity and depressive symptoms, significance did not remain in multiple mediation models (see Table 5). Exploratory analyses (see *supplementary table*) did indicate that the mediation effect may be split across two highly correlated and related variables – self-efficacy and behavioural intentions – and that self-efficacy probably explains the relationship most strongly. This hypothesis is supported in the literature, and Bandura suggests that most behavioural pathways work by ultimately increasing self-efficacy (Bandura, 1977; Koring et al., 2012; Scholz et al., 2008; White et al., 2009). Similarly, for the transport-related domain of physical activity, two individual factors were found to mediate the relationship between transport-related physical activity and depressive symptoms at the single mediation analysis state i.e., self-efficacy and enjoyment of physical activity. When the multiple mediation (see Table 5) analyses were conducted, only self-efficacy remained significantly associated with this relationship. Self-efficacy and enjoyment of physical activity have been identified in existing research as being both critical determinants of physical activity, but also highly correlated (Liang et al., 2007; Motl et al., 2001). These results provide greater insight for designing targeted interventions for this less socioeconomically advantaged cohort of women, in addition to informing some of the public health messages around physical activity and depression.

4.1. Self-efficacy

Whilst the mediating effect was significant across all four domains of physical activity, it was greatest in the domain of leisure-time physical activity. The results of this study are consistent with existing literature where self-efficacy has frequently been cited as a factor mediating the relationship between physical activity and depressive symptoms (Chu et al., 2009; Craft, 2005; McAndrew et al., 2009; Ryan, 2008; White et al., 2009). Self-efficacy has been shown to influence a wide range of health behaviours and physical activity provides for ample opportunities for exposure to develop mastery and goal-setting experiences where self-efficacy can be positively influenced (McAuley et al., 2011; White et al., 2017) Leisure-time and transport-related physical activity might readily allow for the sorts of challenges that offer individuals the chance to develop self-confidence and a sense of mastery (Teychenne et al., 2017). However, the results of this study also provided evidence that self-efficacy significantly mediated the relationship between physical activity and depressive symptoms within the domains of occupational

and domestic physical activity for this cohort. Existing research suggests that these domains of physical activity are likely to provide fewer opportunities to experience a sense of mastery than leisure-time or transport-related physical activity (White et al., 2017). This finding could be explained because women who already have high levels of self-efficacy may be more likely to be engaged in physical activity and that some sort of reciprocal causation is at play in these results, however mediation would have to be tested in reverse to determine this (Cerin, 2010).

4.2. Enjoyment of physical activity

Leisure-time physical activity is associated with individuals actively choosing to undertake recreational activity and is the domain of physical activity where individuals would be most likely to participate for pleasure or for perceived health benefits (Middelweerd et al., 2017; Teychenne et al., 2020; White et al., 2017). The ability to choose to engage in physical activity for enjoyment, which is strongly associated with autonomous motivation, may explain why enjoyment mediated the relationship between leisure-time physical activity and depressive symptoms in the current study. This suggestion is consistent with existing literature (Pickett et al., 2017; White et al., 2017). The results of the present study found that the relationship between transport-related physical activity and depressive symptoms in this cohort was also mediated by the enjoyment of physical activity. This finding is supported by existing studies which posit that self-determination theory may be relevant in explaining the relationship (i.e., where an individual is able to make an autonomous choice to perhaps walk or cycle to work) (Chen et al., 2012; White et al., 2017).

In this study, enjoyment of physical activity did not mediate the relationship between either occupational or domestic physical activity and depressive symptoms. This is perhaps unsurprising, given the likelihood that both occupational or domestic physical activity may be considered obligatory and conditional on others. For example, occupational tasks may be directed by another person (i.e., supervisor or manager) or only carried out in return for payment (i.e., salary). Where activities are conducted under these sorts of circumstances motivation is considered controlled and is often associated with negative affect (Deci & Ryan, 2008; Teychenne et al., 2020; White et al., 2017). These results are supported elsewhere in literature amongst the general adult population (Ainsworth et al., 1999; Chen et al., 2012; Teychenne et al., 2020).

4.3. Behavioural intentions

Behavioural intentions are considered the best predictors of behaviour and behaviour change, and therefore have been considered as a significant component of research in the field of health and lifestyle interventions (Bandura, 1977; Koring et al., 2012; Scholz et al., 2008). The present study found that within the domain of leisure-time physical activity, behavioural intentions were found to play a role in mediating the physical activity - depression relationship. Such evidence supports the premise that behavioural intentions are considered indicative of the strength of a person's motivation towards engaging in a specific behaviour (Hagger et al., 2002; Schifter & Ajzen, 1985).

4.4. Other hypothesised psychosocial mediators

This study sought to explore a broad range of hypothesised psychosocial factors that might explain the relationship between physical activity and depression across the four domains of physical activity and it is notable that only psychological factors were found to significantly mediate this relationship. Whilst these results are supported in the existing research in this area (Chu et al., 2009; Craft, 2005; La Rocque et al., 2021; Ryan, 2008) it is perhaps surprising that the social context of physical activity did not significantly mediate the physical activity – depression relationship. Outside of mediation studies, the social context of physical activity has been posited to play an important role in this relationship (Askari et al., 2017; Fox, 1999; Kandola et al., 2019; Littlecott et al., 2014; Paluska & Schwenk, 2000; Teychenne et al., 2008a). This is the first study that has considered social context of physical activity as a possible mechanism through which physical activity may affect depression in women from low socioeconomic neighbourhoods. Given the depth of theoretically derived support for the social component of physical activity to play a more significant role than our findings indicate, it would perhaps be a valid consideration for future study.

4.5. Strengths and limitations

This is the first prospective study that has explored psychosocial and behavioural factors mediating the relationship between physical activity and depressive symptoms, across all four domains of physical activity, for women from socioeconomically disadvantaged neighbourhoods. The prospective nature of the study allowed for directionality of the relationship to be considered. Another key strength includes the large sample size of an understudied, less socioeconomically advantaged cohort ($n = 1876$) which allowed for the adjustment of several important confounding factors. The use of path analysis allowing for joint modelling of mediation was another strength of this study (Cerin, 2010). Further, the addition of multiple mediation analyses is also a strength and in-line with recommended best practice for mediation studies (Cerin, 2010). The authors acknowledge that this study had a broadly exploratory focus, adopting a deliberately complex model of mediation analysis that sought to explore nine possible mediators across four separate domains of physical activity (36 individual models) that brings with it the risk of spurious findings due to the large number of combinations of exposures and mediators. However, effect estimates and 95% Confidence Intervals are provided allowing readers to draw their own conclusions regarding the weight of results. Other limitations include the use of self-report measures to assess physical activity, potential mediators, and depressive symptoms. Although these measures were valid and reliable, responses may be subjected to response biases, potential recall difficulties and socially desirable responses. Secondly, mediation analyses were conducted using T1 (i.e., baseline) scores for the hypothesised mediators, meaning that cross-sectional data has been used to estimate a hypothesised causal relationship from PA to the mediators, but we cannot rule out the possibility of a bi-directional relationship or reverse causality. However, previous research has shown a prospective/causal effect of physical activity on these mediators (Kandola et al., 2019; Lubans et al., 2016). Despite living in socioeconomically disadvantaged neighbourhoods, women in the sample generally had a high level of education (28.5% had a tertiary degree at baseline) and therefore may not be representative of socioeconomically disadvantaged populations. There is a possibility of selection bias with a relatively high non-response rate at T1 (49%) limiting the generalisability of results alongside the drop-out rate between T1 and T2 (31%). However, response rates were higher than is typical for individuals living in disadvantaged neighbourhoods (approximately 30% compared to 45% in this study) (Sheikh & Mattingly, 1981). The current study found that none of the hypothesised behavioural factors were significantly associated with mediation the physical activity – depressive symptoms relationship (in any domain). It is possible that there may be other untested behavioural mechanisms (e.g., sleep quality) that were not included in this study that may play a significant role (Kandola et al., 2019; Lubans et al., 2016). Broadening the scope of other possible behavioural mechanisms could be the focus of future research.

5. Conclusions

While further research is needed to better understand other potential mediators (e.g., sleep quality and social context of physical activity interventions) the novel findings in this study suggest that self-efficacy, behavioural intentions, and enjoyment of physical activity may be

particularly important factors to consider when designing physical activity interventions to enhance mental health for women living in socioeconomically disadvantaged neighbourhoods. Further, the factors explaining the association between physical activity and depressive symptoms were shown to differ according to the domain in which physical activity is undertaken, highlighting the importance of tailoring health promotion messaging for individual needs and preferences when seeking to leverage the mental health benefits of physical activity.

Funding statement

This study was funded by a National Health and Medical Research Council (NHMRC) Strategic Award, ID 374241. Megan Teychenne is supported by a National Health and Medical Research Council Emerging Leadership Fellowship (APP1195335). The study funder had no role in study design, collection analysis or interpretation of the data in writing the report, or in the decision to submit the article for publication. The contents of the published material are solely the responsibility of the individual authors and do not reflect the view of the funding bodies.

Declaration of competing interest

Given her role as Associate Editor for Mental Health and Physical Activity, Megan Teychenne (co-author) had no involvement in the peer-review of this article and has no access to information regarding its peer-review. Full responsibility for the editorial process for this article was delegated to Editor in Chief.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.mhpa.2023.100560.

References

Ainsworth, B. E., Irwin, M. L., Addy, C. L., Whitt, M. C., & Stolarczyk, L. M. (1999). Moderate physical activity patterns of minority women: The cross-cultural activity participation study. *Journal of Women's Health and Gender-Based Medicine, 8*(6), 805–813.

Allahverdipour, H., Karimzadeh, Z., Alizadeh, N., Asghari Jafarabadi, M., & Javadivala, Z. (2021). Psychological well-being and happiness among middle-aged women: A cross-sectional study. *Health Care for Women International, 42*(1), 28–42. https://doi.org/10.1080/07399332.2019.1703990

Andresen, E. M., Malmgren, J. A., Carter, W. B., & Patrick, D. L. (1994). Screening for depression in well older adults: Evaluation of a short form of the CES-D. *American Journal of Preventive Medicine, 10*(2), 77–84. https://doi.org/10.1016/S0749-3797(18)30622-6

Askari, J., Saberi-Kakhki, A., Taheri, H., & Yassini, S. M. (2017). The effect of aerobic exercise on different symptoms of depression. *An Investigation of Psychological Mechanisms of Stress and Coping. Open Journal of Medical Psychology, 6*(2), 86–102. https://doi.org/10.4236/ojmp.2017.62007

Australian Bureau of Statistics. (2018). Socio-economic indexes for areas. Australian Bureau of statistics. https://www.abs.gov.au/websitedbs/censushome.nsf/home/seifa.

Bailey, M., & McLaren, S. (2005). Physical activity alone and with others as predictors of sense of belonging and mental health in retirees. *Aging & Mental Health, 9*(1), 82–90.

Ball, K., Cleland, V., Salmon, J., Timperio, A. F., McNaughton, S., Thornton, L., Campbell, K., Jackson, M., Baur, L. A., Mishra, G., Brug, J., Jeffery, R. W., King, A., Kawachi, I., & Crawford, D. A. (2013). Cohort profile: The resilience for eating and activity despite inequality (READI) study. *International Journal of Epidemiology, 42*(6), 1629–1639. https://doi.org/10.1093/ije/dys165

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioural change. *Psychological Review, 84*(2), 191–215. https://doi.org/10.1037/0033-295X.84.2.191

Brosse, A. L., Sheets, E. S., Lett, H. S., & Blumenthal, J. A. (2002). Exercise and the treatment of clinical depression in adults: Recent findings and future directions. *Sports Medicine, 32*(12), 741–760. https://doi.org/10.2165/00007256-200232120-00001

Brown, G. W., & Harris, T. O. (1978). *Social origins of depression: A study of psychiatric disorder in women*. Tavistock Publications. https://search.ebscohost.com/login.aspx?direct=true&db=cat00097a&AN=deakin.b1290751&site=eds-live&scope=site.

Cerin, E. (2010). Ways of unravelling how and why physical activity influences mental health through statistical mediation analyses. *Mental Health and Physical Activity, 3*(2), 51–60. https://doi.org/10.1016/j.mhpa.2010.06.002

Chen, L. J., Stevinson, C., Ku, P. W., Chu, D. C., & Chang, Y. K. (2012). Relationships of leisure-time and non-leisure-time physical activity with depressive symptoms: A population-based study of Taiwanese older adults [article]. *International Journal of Behavioral Nutrition and Physical Activity, 9*(28). https://doi.org/10.1186/1479-5868-9-28

Chu, I. H., Buckworth, J., Kirby, T. E., & Emery, C. F. (2009). Effect of exercise intensity on depressive symptoms in women. *Mental Health and Physical Activity, 2*(1), 37–43. https://doi.org/10.1016/j.mhpa.2009.01.001

Craft, L. L. (2005). Exercise and clinical depression: Examining two psychological mechanisms. *Psychology of Sport and Exercise, 6*(2), 151–171.

Craig, C. L., Marshall, A. L., Sjöström, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., Pratt, M., Ekelund, U., Yngve, A., & Sallis, J. F. (2003). International physical activity questionnaire: 12-country reliability and validity. *Medicine & Science in Sports & Exercise, 35*(8), 1381–1395.

Craig, T. J., & Van Natta, P. A. (1979). Influence of demographic characteristics on two measures of depressive symptoms: The relation of prevalence and persistence of symptoms with sex, age, education, and marital status. *Archives of General Psychiatry, 36*(2), 149–154. https://doi.org/10.1001/archpsyc.1979.01780020039003

Cusatis, R., & Garbarski, D. (2019). Different domains of physical activity: The role of leisure, housework/care work, and paid work in socioeconomic differences in reported physical activity. *SSM - Population Health, 7*. https://doi.org/10.1016/j.ssmph.2019.100387

Deci, E. L., & Ryan, R. M. (2008). Facilitating optimal motivation and psychological well-being across life's domains. *Canadian Psychology, 49*(1), 14–23. https://doi.org/10.1037/0708-5591.49.1.14

Dillman, D. A. (1982). A SUMMARY: Mail and telephone surveys: The total design method. *The Journal of Continuing Higher Education, 30*(2), 14–15. https://doi.org/10.1080/07377366.1982.10401298

Ekkekakis, P. (2013). *Routledge handbook of physical activity and mental health*. Taylor & Francis Group. http://ebookcentral.proquest.com/lib/deakin/detail.action?docID=1356328.

Fox, K. R. (1999). The influence of physical activity on mental well-being. *Public Health Nutrition, 2*(3a), 411–418. https://doi.org/10.1017/s1368980099000567

Giles-Corti, B., & Donovan, R. J. (2003). Relative influences of individual, social environmental, and physical environmental correlates of walking. *American Journal of Public Health, 93*(9), 1583–1589. https://doi.org/10.2105/ajph.93.9.1583

Greden, J. F. (2001). The burden of recurrent depression: Causes, consequences, and future prospects. *Journal of Clinical Psychiatry, 62*(Suppl 22), 5–9.

Hagger, M. S., Chatzisarantis, N. L. D., & Biddle, S. J. H. (2002). The influence of autonomous and controlling motives on physical activity intentions within the Theory of Planned Behaviour. *British Journal of Health Psychology, 7*(3), 283. https://doi.org/10.1348/135910702760213689

Hayes, A. F., & Scharkow, M. (2013). The relative trustworthiness of inferential tests of the indirect effect in statistical mediation analysis: Does method really matter? *Psychological Science, 24*(10), 1918–1927. https://search.ebscohost.com/login.aspx?direct=true&db=edsjsr&AN=edsjsr.24539385&site=eds-live&scope=site.

Imai, K., Keele, L., & Tingley, D. (2010). A general approach to causal mediation analysis. *Psychological Methods, 15*(4), 309–334. https://doi.org/10.1037/a0020761, 334.

Kandola, A., Ashdown-Franks, G., Hendrikse, J., Sabiston, C. M., & Stubbs, B. (2019). Physical activity and depression: Towards understanding the antidepressant mechanisms of physical activity. *Neuroscience & Biobehavioral Reviews, 107*, 525–539. https://doi.org/10.1016/j.neubiorev.2019.09.040

Kendzierski, D., & DeCarlo, K. J. (1991). Physical activity enjoyment scale: Two validation studies. *Journal of Sport & Exercise Psychology, 13*(1), 50–64.

Koring, M., Richert, J., Parschau, L., Ernsting, A., Lippke, S., & Schwarzer, R. (2012). A combined planning and self-efficacy intervention to promote physical activity: A multiple mediation analysis. *Psychology Health & Medicine, 17*(4), 488–498. https://doi.org/10.1080/13548506.2011.608809

Kull, M., Ainsaar, M., Kiive, E., & Raudsepp, L. (2012). Relationship between low depressiveness and domain specific physical activity in women. *Health Care for Women International, 33*(5), 457–472. https://doi.org/10.1080/07399332.2011.645968

La Rocque, C. L., Mazurka, R., Stuckless, T. J. R., Pyke, K., & Harkness, K. L. (2021). Randomized controlled trial of bikram yoga and aerobic exercise for depression in women: Efficacy and stress-based mechanisms. *Journal of Affective Disorders, 280*(A), 457–466. https://doi.org/10.1016/j.jad.2020.10.067

Leach, L. S., Christensen, H., Mackinnon, A. J., Windsor, T. D., & Butterworth, P. (2008). Gender differences in depression and anxiety across the adult lifespan: The role of psychosocial mediators. *Social Psychiatry and Psychiatric Epidemiology, 43*(12), 983–998. https://doi.org/10.1007/s00127-008-0388-z

Lechner, L., Bolman, C., & Van Dijke, M. (2006). Factors related to misperception of physical activity in The Netherlands and implications for health promotion programmes. *Health Promotion International, 21*(2), 104–112. https://doi.org/10.1093/heapro/dal011

Leith, L. M. (2010). *Foundations of exercise and mental health*. Fitness Information Technology. https://books.google.com.au/books?id=-Q1xQgAACAAJ.

Liang, H., Motl, R. W., McAuley, E., & Konopack, J. F. (2007). Effects of self-efficacy on physical activity enjoyment in college-aged women. *International Journal of Behavioural Medicine, 14*(2), 92–96. https://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=26989626&site=eds-live&scope=site.

Littlecott, H. J., Moore, G. F., Moore, L., & Murphy, S. (2014). Psychosocial mediators of change in physical activity in the Welsh national exercise referral scheme: Secondary

analysis of a randomised controlled trial. *International Journal of Behavioral Nutrition and Physical Activity, 11*(1). https://doi.org/10.1186/s12966-014-0109-9

Lubans, D., Richards, J., Hillman, C., Faulkner, G., Beauchamp, M., Nilsson, M., Kelly, P., Smith, J., Raine, L., & Biddle, S. (2016). Physical activity for cognitive and mental health in youth: A systematic review of mechanisms. *Paediatrics, 138*(3), Article e20161642. https://doi.org/10.1542/peds.2016-1642

Marcus, B. H., Selby, V. C., Niaura, R. S., & Rossi, J. S. (1992). Self-efficacy and the stages of exercise behaviour change. *Research Quarterly for Exercise & Sport, 63*(1), 60–66. https://doi.org/10.1080/02701367.1992.10607557

Marks, G., Webb, K., Rutishauser, I., & Riley, M. (2001). *Monitoring food habits in the Australian population using short questions*. National Food and Nutrition Monitoring and Surveillance Project.

McAndrew, L. M., Napolitano, M. A., Albrecht, A., Farrell, N. C., Marcus, B. H., & Whiteley, J. A. (2009). When, why and for whom there is a relationship between physical activity and menopause symptoms. *Maturitas, 64*(2), 119–125. https://doi.org/10.1016/j.maturitas.2009.08.009

McAuley, E., Szabo, A., Gothe, N., & Olson, E. A. (2011). Self-efficacy: Implications for physical activity, function, and functional limitations in older adults. *American Journal of Lifestyle Medicine, 5*(4). https://doi.org/10.1177/1559827610392704

Middelweerd, A., Velde, S. J. T., Abbott, G., Timperio, A., Ball, K., & Brug, J. (2017). Do intrapersonal factors mediate the association of social support with physical activity in young women living in socioeconomically disadvantaged neighbourhoods? A longitudinal mediation analysis. *PLoS One, 12*(3). https://doi.org/10.1371/journal.pone.0173231

Motl, R. W., Dishman, R. K., Saunders, R., Dowda, M., Pate, R. R., & Felton, G. (2001). Measuring enjoyment of physical activity in adolescent girls. *American Journal of Preventive Medicine, 21*(2), 110–117. https://doi.org/10.1016/S0749-3797(01)00326-9, 117.

Murphy, B., Benson, T., Elliott, C., Dean, M., Lavelle, F., McCloat, A., & Mooney, E. (2021). Changes in consumers' food practices during the covid-19 lockdown, implications for diet quality and the food system: A cross-continental comparison. *Nutrients, 13*(1), 1–14. https://doi.org/10.3390/nu13010020

Noble, R. E. (2005). Depression in women. *Journal of Metabolism – Clinical and Experimental, 54*(5), 49–52. https://doi.org/10.1016/j.metabol.2005.01.014

Paluska, S. A., & Schwenk, T. L. (2000). Physical activity and mental health: Current concepts. *Sports Medicine, 29*(3), 167–180. https://doi.org/10.2165/00007256-200029030-00003

Peddie, N., Westbury, T., & Snowden, A. (2020). 'Nobody will put baby in the corner!': A qualitative evaluation of a physical activity intervention to improve mental health. *Health and Social Care in the Community, 28*(6), 2060–2075. https://doi.org/10.1111/hsc.13017

Pickett, K., Kendrick, T., & Yardley, L. (2017). "A forward movement into life": A qualitative study of how, why and when physical activity may benefit depression. *Mental Health and Physical Activity, 12*, 100–109. https://doi.org/10.1016/j.mhpa.2017.03.004

Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement, 1*, 385–401. https://doi.org/10.1177/014662167700100306

Ryan, M. P. (2008). The antidepressant effects of physical activity: Mediating self-esteem and self-efficacy mechanisms. *Psychology and Health, 23*(3), 279–307. https://doi.org/10.1080/14768320601185502

Salmon, J., Crawford, D., Owen, N., Bauman, A., & Sallis, J. F. (2003). Physical activity and sedentary behaviour: A population-based study of barriers, enjoyment, and preference. *Health Psychology, 22*(2), 178–188. https://doi.org/10.1037/0278-6133.22.2.178

Schifter, D. E., & Ajzen, I. (1985). Intention, perceived control, and weight loss: An application of the theory of planned behaviour. *Journal of Personality and Social Psychology, 49*(3), 843–851. https://doi.org/10.1037/0022-3514.49.3.843

Scholz, U., Schüz, B., Ziegelmann, J. P., Lippke, S., & Schwarzer, R. (2008). Beyond behavioural intentions: Planning mediates between intentions and physical activity. *British Journal of Health Psychology, 13*(3), 479–494. https://doi.org/10.1348/135910707x216062

Sheikh, K., & Mattingly, S. (1981). Investigating non-response bias in mail surveys. *Journal of Epidemiology & Community Health, 35*(4), 293–296. https://search.ebscohost.com/login.aspx?direct=true&db=edsjsr&AN=edsjsr.25566283&site=eds-live&scope=site.

Teychenne, M., Abbott, G., Lamb, K. E., Rosenbaum, S., & Ball, K. (2017). Is the link between movement and mental health a two-way street? Prospective associations between physical activity, sedentary behaviour and depressive symptoms among women living in socioeconomically disadvantaged neighbourhoods. *Preventive Medicine, 102*, 72–78. https://doi.org/10.1016/j.ypmed.2017.07.005

Teychenne, M., Ball, K., & Salmon, J. (2008a). Associations between physical activity and depressive symptoms in women. *International Journal of Behavioral Nutrition and Physical Activity, 5*(27). https://doi.org/10.1186/1479-5868-5-27

Teychenne, M., Ball, K., & Salmon, J. (2008b). Physical activity and likelihood of depression in adults: A review. *Preventive Medicine, 46*(5), 397–411. https://doi.org/10.1016/j.ypmed.2008.01.009

Teychenne, M., White, R. L., Richards, J., Schuch, F. B., Rosenbaum, S., & Bennie, J. A. (2020). Do we need physical activity guidelines for mental health: What does the evidence tell us? *Mental Health and Physical Activity, 18*. https://doi.org/10.1016/j.mhpa.2019.100315

Valeri, L., & Vanderweele, T. J. (2013). Mediation analysis allowing for exposure-mediator interactions and causal interpretation: Theoretical assumptions and implementation with SAS and SPSS macros. *Psychological Methods, 18*(2), 137–150. https://doi.org/10.1037/a0031034

Vella, S. A., Aidman, E., Teychenne, M., Smith, J. J., Swann, C., Rosenbaum, S., White, R. L., & Lubans, D. R. (2023). Optimising the effects of physical activity on mental health and wellbeing: A joint consensus statement from sports medicine Australia and the Australian psychological society. *Journal of Science and Medicine in Sport*. https://doi.org/10.1016/j.jsams.2023.01.001 (in press).

White, R. L., Babic, M. J., Parker, P. D., Lubans, D. R., Astell-Burt, T., & Lonsdale, C. (2017). Domain-specific physical activity and mental health: A meta-analysis. *American Journal of Preventive Medicine, 52*(5), 653–666. https://doi.org/10.1016/j.amepre.2016.12.008

White, K., Kendrick, T., & Yardley, L. (2009). Change in self-esteem, self-efficacy, and the mood dimensions of depression as potential mediators of the physical activity and depression relationship: Exploring the temporal relation of change [Article]. *Mental Health and Physical Activity, 2*(1), 44–52. https://doi.org/10.1016/j.mhpa.2009.03.001

Update

Mental Health and Physical Activity

Volume 27, Issue , October 2024, Page

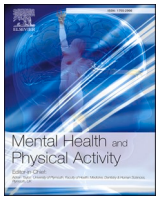
DOI: https://doi.org/10.1016/j.mhpa.2024.100644

Mental Health and Physical Activity 27 (2024) 100644

Contents lists available at ScienceDirect

Mental Health and Physical Activity

journal homepage: www.elsevier.com/locate/menpa



Corrigendum to "Investigating psychosocial and behavioural mediators of the relationship between physical activity and depressive symptoms in women from socioeconomically disadvantaged neighbourhoods" [Mental Health and Physical Activity 25 (2023) 100560]

Thea Baker [a,b,*], Rhiannon White [c], Gavin Abbott [a,b], Eloise Litterbach [a,b], Megan Teychenne [a,b]

[a] Deakin University, Geelong, Australia
[b] Institute for Physical Activity and Nutrition (IPAN), School of Exercise and Nutrition Sciences, Australia
[c] School of Health Sciences, Western Sydney University, Penrith, NSW, Australia

The journal regrets that the abstract of the original paper was missed in publication.

Abstract

Background

The association between physical activity and depressive symptoms is dependent on the domain in which physical activity is undertaken. Yet, the underlying mechanisms explaining these differing associations are unknown. This study sought to investigate psychosocial and behavioural mediators of the relationship between domain-specific physical activity and depressive symptoms in women from socioeconomically disadvantaged neighbourhoods.

Methods

Participants were 1876 women aged 18–45 years, from socioeconomically disadvantaged neighbourhoods. Women self-reported physical activity in four domains (leisure-time, transport-related, occupational, domestic), depressive symptoms (CES-D 10), and psychosocial and behavioural factors, at two time points (2007/2008; 2010/2011). Mediation analysis estimated the contribution of each potential mediator to the relationship between baseline physical activity and depressive symptoms at follow-up.

Results

Self-efficacy mediated the relationship between physical activity and depressive symptoms, across all physical activity domains (leisure-time: $\beta = -.018$ [95% CI -.033, −.003], transport-related: $\beta = -.007$ [95% CI -.013, −.002], occupational: $\beta = -.008$ [95% CI -.016, −.002], domestic: $\beta = -.004$ [95% CI -.009, −.0002]). Enjoyment of physical activity also mediated relationships between leisure-time ($\beta = -.016$ [95% CI -.030, −.001]) and transport-related physical activity ($\beta = -.003$ [95% CI -.008, −.000]) and depression. Behavioural intentions mediated the relationship between leisure-time physical activity and depression only ($\beta = -.012$ [95% CI -.024, −.0002]).

Discussion

Physical activity interventions aimed at improving depressive symptoms should support self-efficacy, enjoyment, and behavioural intentions to maximise the benefit of physical activity.

Keywords: physical activity; exercise; depressive symptoms; mental health; psychosocial factors; behavioural factors; mediators; women; socio-economic disadvantage.

The journal would like to apologise for any inconvenience caused.

DOI of original article: https://doi.org/10.1016/j.mhpa.2023.100560.

* Corresponding author. School of Exercise and Nutrition Sciences, Deakin University, 221 Burwood Hwy, Burwood, VIC, 3125, Australia.
E-mail address: thea.baker@deakin.edu.au (T. Baker).

https://doi.org/10.1016/j.mhpa.2024.100644

Available online 29 October 2024