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Do intrapersonal factors mediate the association of social support with physical activity in young women living in socioeconomically disadvantaged neighbourhoods? A longitudinal mediation analysis

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Abstract

Background

Levels of physical activity (PA) decrease when transitioning from adolescence into young adulthood. Evidence suggests that social support and intrapersonal factors (self-efficacy, outcome expectations, PA enjoyment) are associated with PA. The aim of the present study was to explore whether cross-sectional and longitudinal associations of social support from family and friends with leisure-time PA (LTPA) among young women living in disadvantaged areas were mediated by intrapersonal factors (PA enjoyment, outcome expectations, self-efficacy).

Methods

Survey data were collected from 18–30 year-old women living in disadvantaged suburbs of Victoria, Australia as part of the READI study in 2007–2008 (T0, N = 1197), with follow-up data collected in 2010–2011 (T1, N = 357) and 2012–2013 (T2, N = 271). A series of single-mediator models were tested using baseline (T0) and longitudinal data from all three time points with residual change scores for changes between measurements.

Results

Cross-sectional analyses showed that social support was associated with LTPA both directly and indirectly, mediated by intrapersonal factors. Each intrapersonal factor explained between 5.9–37.5% of the associations. None of the intrapersonal factors were significant mediators in the longitudinal analyses.

Conclusions

Results from the cross-sectional analyses suggest that the associations of social support from family and from friends with LTPA are mediated by intrapersonal factors (PA enjoyment, outcome expectations and self-efficacy). However, longitudinal analyses did not confirm these findings.

Introduction

Although the positive health effects of physical activity (PA) are well known [1–4], only approximately 30% of the Australian adult population meet the recommended guidelines of at least 30 minutes of moderate-intensity PA per day. [5] Only 48.7% of young Australian women aged 18–24 years meet the recommended PA guidelines and the percentages tend to decline substantially in older age groups. [5, 6] Previous research has shown that PA levels decrease during the transition from adolescence into adulthood. [6, 7] Life events that occur in young adulthood, such as leaving school and home, getting married or having children, may be associated with disruption in PA during this life stage [7], especially for women. [8, 9] Furthermore, women living in the most socioeconomically disadvantaged areas already are less physically active than those from more advantaged neighbourhoods, and thus are even more at risk of adverse health outcomes resulting from age-related declines in PA. [10]

In order to minimise reductions in PA in young adults living in disadvantaged neighbourhoods, we need to understand the determinants of PA in this population group.

Various social-cognitive and ecological-based models have been published which aim to predict and understand health behaviours.[11] These models and theories describe a range of potential behavioural determinants, e.g. environmental factors such as availability and socio-cognitive factors such as self-efficacy and social support. Often used theories and models are the Social Cognitive Theory (SCT)[12–14] and socio-ecological models [15]. These models postulate that the social environment influences health behaviours, such as PA, both directly and indirectly (i.e. through self-efficacy). That the social environment is indeed an important determinant of PA has been confirmed in observational research.[16–18]Moreover, self-efficacy, or similar constructs, is a key construct within various social cognitive theories and has consistently positively been associated with PA. [18, 19] Outcome expectations, another key concept in the SCT, represent one's beliefs about the consequences and perceived benefits of one's behavior such as participating in PA and has consistently been associated with PA. [20]

In addition, expected enjoyment from physical activities, which can be seen as an indicator of intrinsic motivation, has been positively associated with PA. [21] Overall, cognitive factors (e.g., self-efficacy, outcome expectations (i.e., perceived health benefits) and expected PA enjoyment) and social support have been found to be positively associated with PA levels. [11, 18, 22, 23] However, the underlying mechanisms and inter-relationships by which these factors might influence PA are largely unknown. A better insight in these inter-relationships would further improve theoretical models and our understanding of PA and other health behaviours. [22, 24, 25] Recent studies indicate that cognitive factors such as self-efficacy mediate the association of social support and PA. [25–27]. This means that social environmental factors, such as social support, would positively influence cognitive factors such as self-efficacy, which in turn positively influences PA. However, these results are derived from cross-sectional mediation studies and should be interpreted with caution due to their inability to identify temporal or causal effects and pathways. [28] Consequently, there is a need for

longitudinal and experimental approaches aiming to explore the mechanisms underlying relationships between social factors and PA. As there are various important potential mediators described in models, theories and the literature, the current study examines a subset of these potential mediators that were available in the cohort study. The current study aimed to examine the associations between social support from family and friends with leisure time PA (LTPA) in young Australian women (aged 18–30 years) living in disadvantaged neighbourhoods and to explore whether these associations were mediated by intrapersonal factors (i.e. PA enjoyment, outcome expectations, self-efficacy) using cross-sectional and longitudinal data. We hypothesized that the association of social support and LTPA would be mediated by cognitive factors. That is, a supportive network of family and friends can facilitate LTPA, because social support may also promote PA enjoyment, outcome expectations, and self-efficacy to be physically active.

Methods

Procedure and participants

This study used data from the Resilience for Eating and Activity Despite Inequality (READI) cohort. The READI study collected self-reported data using mailed surveys in 2007–08 (baseline = T0), 2010–2011 (3 year follow-up = T1) and 2012–2013 (5 year follow-up = T2). [29] The study was developed to examine socioeconomic variations in PA and diet in Australian women aged 18–46 years living in disadvantaged neighbourhoods. [29] Participants were recruited from 80 socioeconomically disadvantaged neighbourhoods (40 urban and 40 rural) via a stratified random sampling approach using the electoral roll in Victoria Australia. Detailed information about the READI cohort is provided in the cohort profile. [29] The present study will solely report results from women aged 18–30 years at T0, and uses T0 (N = 1197), T1 (N = 348) T2 (N = 267) data.

The study protocol was approved by the Deakin University Human Research Ethics Committee, the Victorian Department of Education and the Catholic Education Office, and informed consent was obtained from each participant before the study started.

Measurement

Analyses are based on survey data of LTPA, social support from family and from friends, PA enjoyment, self-efficacy, outcome expectations and demographic characteristics. Appendix 1 shows a summary of the social support and intrapersonal measures and their internal reliability and test-retest reliability.

Outcome variable. Physical activity was assessed at all three time points using the International Physical Activity Questionnaire Long version (IPAQ-L), which has acceptable measurement properties. [30] LTPA, the outcome variable, was assessed with six items of the IPAQ-L where participants reported time spent in walking, moderate- and vigorous-intensity PA in their leisure time during the past 7 days. LTPA was a sum-score of minutes per week of walking, or in moderate- and vigorous-intensity PA during leisure time.

Predictor variable. Perceived social support for PA from friends was assessed with two items using a 5-point Likert scale (1 Never– 5 Very often). [31] Whereas, social support from family was assessed using two items and a 6-point Likert scale (1 Never– 5 Very often. 6 Not Applicable).[31] Sum scores were computed for social support from family and for social support from friends for each time point (range = 2–10). For social support from family, ' Not Applicable' was treated as missing and therefore did not contribute to the summed score.

Mediator variables. PA Enjoyment was assessed with six items using a 7-point scale assessing how the participants feel about PA at the moment (e.g. 1 I hate it– 7 I enjoy it; 1 I feel

bored– 7 I feel interested). [32] A sum score (range = 6–42) was computed for each time point (Cronbach's α = 0.93–0.95).

Physical activity outcome expectations were assessed with six items using a 4-point Likert scale (1 No reason at all– 4 A very important reason). The items captured how important health, appearance, weight, feeling fit, relaxation and stress relief are for being physically active. [25] A sum score (range = 6–24) was computed for each time point (Cronbach's α = 0.75–0.79).

Self-efficacy for PA was assessed with five items using a 5-point Likert scale (1 Not at all confident– 5 extremely confident) assessing how confident the participants are that they could do PA in different situations (e.g. ". . .even when I am tired"). [33] A sum score (range = 5–25) was computed for each time point (Cronbach's α = 0.80–0.86).

Demographics.   Information about age, education level (low: <Year 12; medium: Year 12/trade/certificate; High: university/postgraduate), marital status (married/living as married; separated/ divorced/widowed; never been married), and children living at home (yes/no) were collected in the survey.
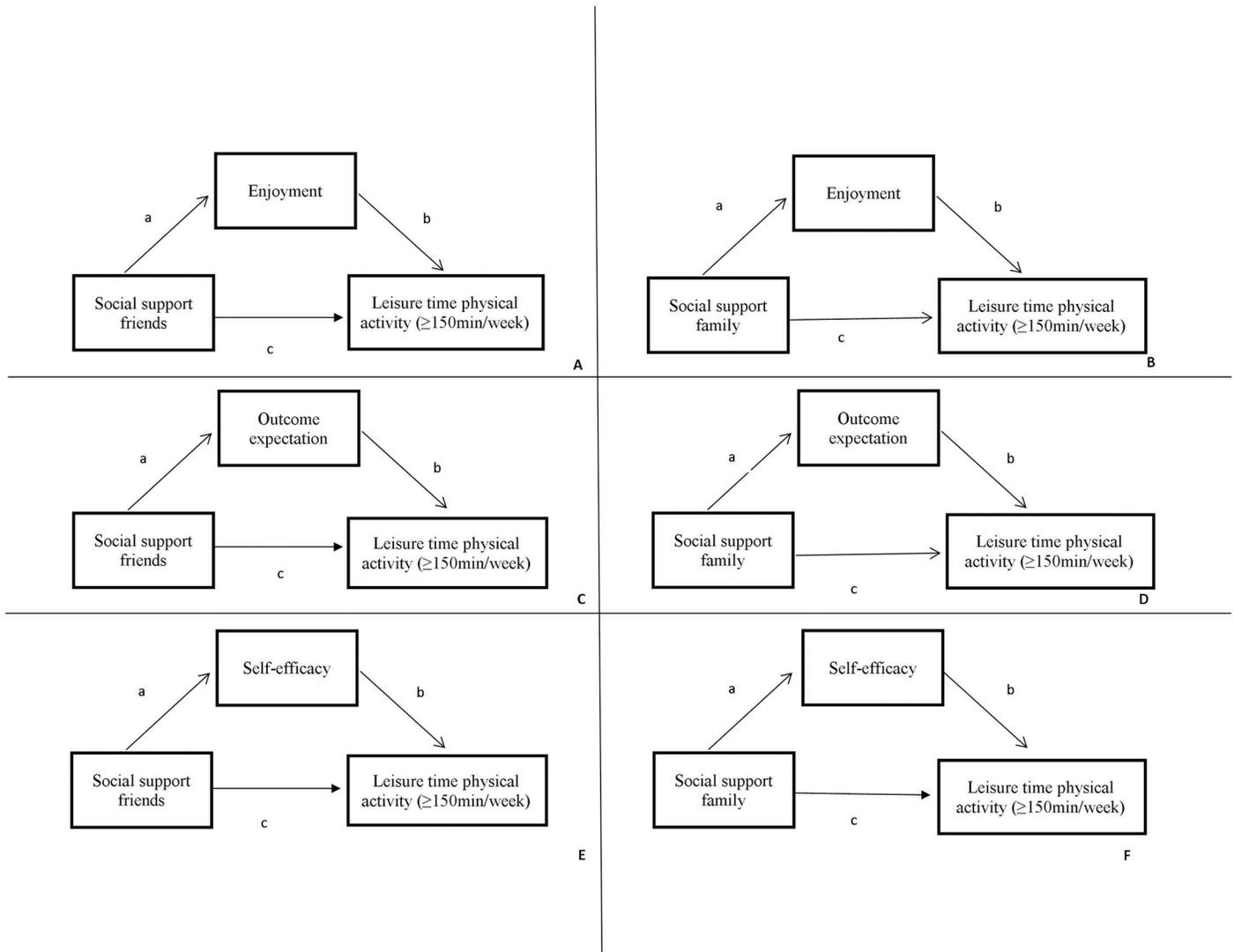
Analyses

For the three time points, means and standard deviations or proportions were calculated for all variables. Repeated measures ANOVA were conducted to examine whether LTPA, social support from family and friends, PA enjoyment, outcome expectation, and self-efficacy changed over time (T0-T1-T2).

Analyses were conducted to examine associations between social support from family and friends and LTPA and whether these associations were mediated by three intrapersonal factors (PA enjoyment, outcome expectation, self-efficacy). Single mediator analyses were separately conducted for two exposures: social support from family and from friends; thus in total six mediation models were tested to explore whether the associations for social support and LTPA were mediated by intrapersonal factors (Fig 1). It is commonly considered that mediation is present when a potential mediator is significantly associated with the predictor variable and with the outcome variable while adjusting for the predictor. [34] Therefore, a series of regression analyses were conducted using a four step process: 1) the total association of social support with LTPA was estimated (path *c*, Figs 1 and 2); 2) the independent association of social support with LTPA adjusted for the potential mediators were estimated (path *c'* and *b*, Figs 1 and 2); 3) the association of social support with potential mediators was estimated (path *a*, Figs 1 and 2); and 4) the mediated effect was calculated as the product of the *a* and *b* paths, and bias-corrected bootstrapping was used to produce 95% confidence intervals of the mediated effect. [35] The proportion mediated effect was calculated as the product of *a* and *b* paths divided by *c* path.

In the first step, a cross-sectional analyses were conducted using the baseline data (T0) from 1197 participants. LTPA (at T0) was dichotomized at 150 minutes per week due to the zero-inflated distribution. The associations of social support with each potential mediator were estimated (path a, Fig 1) with linear regression models and the total and independent associations (path b, c and c') were estimated with logistic regression models. In order to estimate the mediated effect the regression coefficient of the *c* path needed to be standardized. [36]

By definition, mediation implies change over time, which cannot be captured in cross-sectional designs. Cross-sectional data analyses can therefore lead to over- or under-estimated effects. [28, 37] To overcome this, longitudinal mediation models were used that accounted for changes over time in predictors, mediators and outcomes and their associations. To optimally

Fig 1. Conceptual mediation model for the cross-sectional analyses. A-F Conceptual model of the direct and indirect association of social support (i.e. from friends/colleagues and from family) personal determinants (PA enjoyment, self-efficacy and outcome expectations) and leisure-time physical activity (≥150minutes/week) for the cross-sectional analyses.

use the available data, a model as depicted in Fig 2 was used. Change scores—using a continuous scale—were calculated as residual changes scores for changes between two measurements in minutes per week (i.e., $X\Delta T0\text{-}1$, $M\Delta T0\text{-}1$, $Y\Delta T1\text{-}2$) as proposed by Twisk and Proper. [38] These longitudinal models used data from 271 women who completed surveys at all three time points. Changes in social support between T0-T1 were hypothesized to predict changes in LTPA between T1-T2 with changes in intrapersonal factors between T0-T1 as possible mediators (Fig 2).

Single mediation analyses were conducted using both cross-sectional and longitudinal data. As the sample size in the longitudinal data set was too limited to conduct multiple mediation analyses, for consistency and comparability we did not perform multiple mediation models with the cross-sectional data either, allowing the results from the cross-sectional and longitudinal data to be comparable. All analyses were adjusted for women's level of education, whether
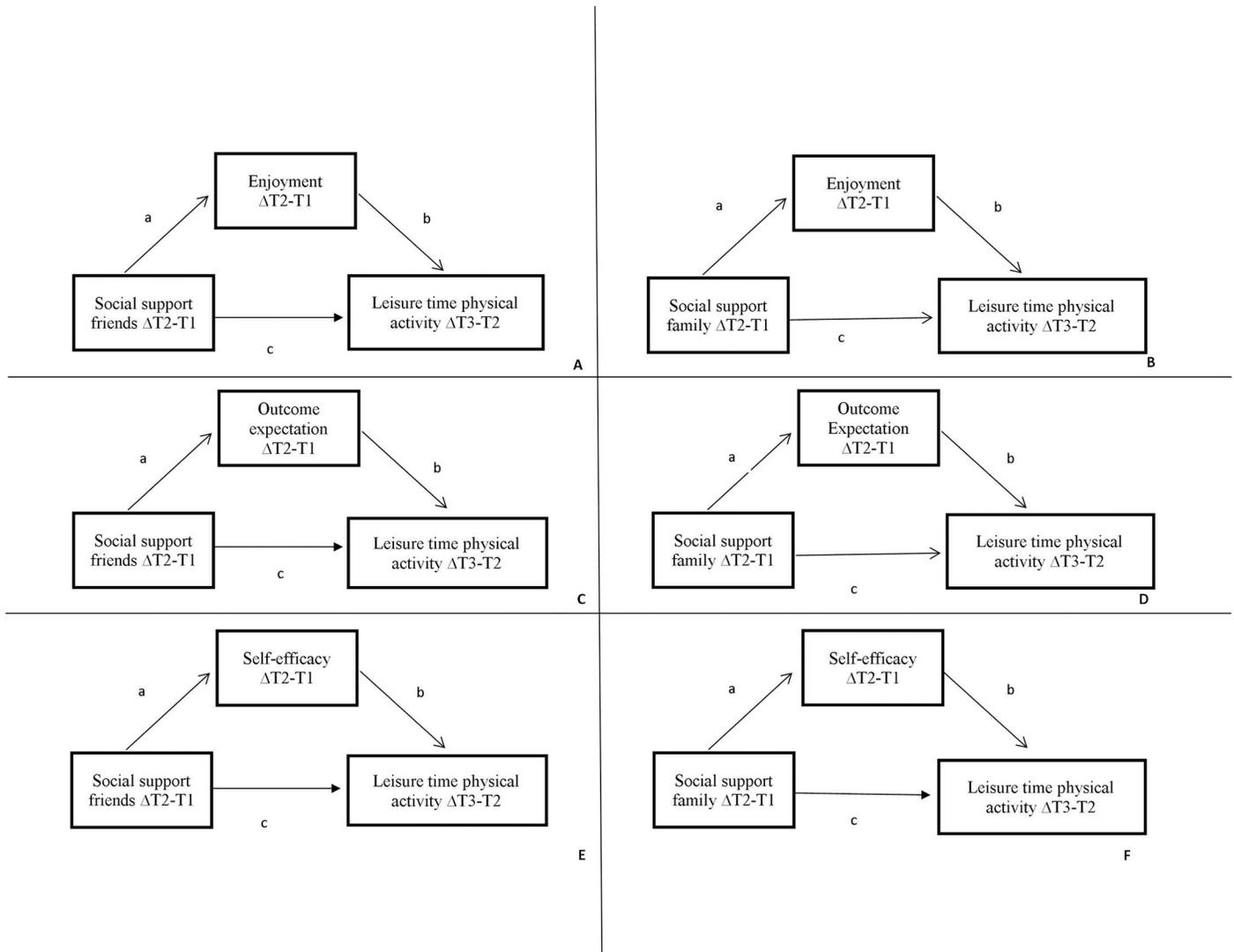
Fig 2. Conceptual model for the longitudinal analyses using residual change scores. A-F Conceptual models of the direct and indirect association of changes in social support from friends and from colleagues and family, changes in personal determinants (PA enjoyment of physical activity, self-efficacy for physical activity and outcome expectations and changes in leisure-time physical activity.

they had any children living at home, and area of residence (urban or rural); robust standard errors were used to account for potential clustering within the 80 neighbourhoods. Analyses were conducted in 2015 using Stata 12 (StataCorp, TX).

Non-response analyses. Because of the high attrition rate, a response analyses was conducted to compare baseline characteristics between responders (N = 271) and non-responders (N = 926). Non-responders were those who either dropped out at T1 (N = 840) or at T2 (N = 86). No significant differences between groups were found, except for age and region of residence. The non-responders were on average younger (24.0 vs 24.7 years, p = 0.005) and a higher percentage lived in urban areas (58.8% vs 48.0%, $p = 0.003$). Results of the non-response analyses are presented in Appendix 2.

Table 1. Participant's characteristics for all three time points (T0-2).

	T0 (2007–08)	T1 (2010–11)	T2 (2012–13)
Number of participants [N]	1197	357	271
Age [years]	24.2 (3.4)	27.2 (3.4)	29.2 (3.4)
BMI [kg/m^2]	24.5 (5.8)	25.4 (6.0)	25.7 (6.4)
Education [%]			
High[1]	27	38	47
Medium[2]	63	60	51
Low[3]	9	2	1
Marital status [%]			
Married/living as married	38	51	57
Separated/divorced/widowed	3	3	3
Never married	59	46	40
Children living with you [Yes; %]	33	39	40

Note. T0 = baseline, T1 = 3 year follow-up, T2 = 5 year follow-up

[1] High education level: university/postgraduate

[2] Medium education level: Year 12/trade/certificate

[3] Low education level: <Year 12

Results

Women's mean age at baseline was 24.2 years, and about 60% of the sample had an intermediate level of education (i.e., completed high school, a trade certificate or diploma), were not married, and had no children living with them. Table 1 provides additional participant characteristics.

There were no significant differences across the three time points for LTPA, social support from family and friends or intrapersonal factors as indicated by the non-significant F-values (Table 2).

Association of social support variables with leisure-time physical activity (c-path)

Cross-sectional logistic regression analyses showed that social support from family and friends were both significantly positively associated with participation in ≥150 minutes per week of LTPA (Table 3). Longitudinal analyses showed no significant associations of changes in social support from family and friends from baseline (T0) to 3 year follow-up (T1), with changes in LTPA from 3 year follow-up (T1) to 5 year follow-up (T2) (Table 4).

Association of social support variables with intrapersonal factors (a-path)

Cross-sectional linear regression analyses showed that social support from family and friends were both significantly positively associated with PA enjoyment, outcome expectancy and self-efficacy for PA at baseline (Table 3). Longitudinal analyses showed that changes in social support from family between T0 and T1 were positively significantly associated with changes in outcome expectations between T0 and T1 (B = 0.21, 95%CI = 0.05–0.37) (Table 4). Changes in social support from friends from T0-T1 were positively significantly associated with changes in self-efficacy from T0-T1 (B = 0.29, 95%CI = 0.08–0.51) (Table 4).

Table 2. Descriptive statistics (number of participants (N), percentages (%), means and Standard Deviations (SD) and) for the three time points (T0-2), changes between two time points (T1-T0, T2-T1) and the time-effects.

Measurement	Number of participants (N)	Leisure-Time Physical activity [min/week]	Leisure-Time Physical activity (> = 150 minutes/week)	Social Support Family	Social Support Friends	Enjoyment	Outcome Expectancy	Self-Efficacy
Time point	N	Mean (SD)	N (%)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
T0	1197	228.0 (250.6)	567 (48.6%)	6.1 (2.2)	4.8 (2.2)	31.3 (7.3)	18.4 (3.7)	13.5 (4.3)
T1	348	231.5 (279.0)	173 (49.4%)	6.1(2.1)	5.0 (2.3)	31.8 (7.4)	18.5 (3.4)	13.4 (4.4)
T2	267	201.8 (221.9)	129 (48.3%)	6.0 (2.3)	4.9 (2.3)	31.8 (8.3)	18.8 (3.4)	13.6 (4.9)
ΔTime points[1]	N	Mean (Range)	N (%)	Mean(Range)	Mean (Range)	Mean (Range)	Mean (Range)	Mean (Range)
T_{1-0}	348	-1.2 (-1020; 1560)	NA[2]	-0.0 (-5;8)	0.1 (-8;8)	0.2 (-28;23)	0.2 (-12; 11)	-0.1 (-15; 14)
T_{2-1}	267	-25.5 (-1050;1320)	NA[2]	-0.0 (-6;7)	-0.2 (-7;8)	-0.2 (-27;19)	0.3 (-12;9)	0.0 (-14;18)
Time-effects	N	F (p-value)[3]	NA[2]	F (p-value)[3]	F (p-value)[3]	F (p-value)[3]	F (p-value)[3]	F (p-value)[3]
	235	1.43 (p = 0.24)	NA[2]	0.3 (p = 0.74)	0.94 (p = 0.39)	0.72 (p = 0.49)	1.94 (p = 0.15)	0.06 (p = 0.94)

Note. T0 = baseline, T1 = 3 year follow-up, T2 = 5 year follow-up

[1] Changes in Leisure-time physical activity, social support from family and from friends, PA enjoyment, outcome expectations and self-efficacy between measurement at T0 and T1 (T1-T0) and between T1 and T2 (T2-T1), respectively.

[2] Not applicable (NA) for difference between time points

[3] F-value calculated with the repeated measures ANOVA with $df_{time} = 2$, $df_{residuals} = 468$ and the p-value

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Association of intrapersonal factors with leisure-time physical activity (b-path)

Cross-sectionally, all hypothesized mediators (PA enjoyment, outcome expectations, self-efficacy) were significantly positively associated with LTPA adjusted for social support from friends. Furthermore, all hypothesized mediators (PA enjoyment, outcome expectations, self-efficacy) were significantly positively associated with LTPA adjusted for social support from family (Table 3) as well. Longitudinal analyses showed that none of the changes between T0 and T1 in the hypothesized mediators (PA enjoyment, outcome expectations, self-efficacy) were significantly associated with changes in LTPA from T1-T2 adjusted for either changes in social support from family or friends from T0-T1 (Table 4).

Mediating effects of intrapersonal factors

Results from cross-sectional analyses showed that all hypothesized mediators (PA enjoyment, outcome expectations, self-efficacy) had significant roles as mediators, with each intrapersonal factor mediating between 5.9–37.5% of the total associations. Results from the longitudinal analyses showed that none of the intrapersonal factors (PA enjoyment, outcome expectations, self-efficacy) had significant roles as mediators (Table 4).

Discussion

The current study aimed to examine the associations of social factors (social support from family and from friends) and LTPA in young Australian women (aged 18–30 years) living in disadvantaged neighbourhoods and to explore whether these associations were mediated by PA enjoyment, outcome expectations and self-efficacy, using cross-sectional and longitudinal data. Our hypothesis that the association of social support and LTPA was mediated by these

Table 3. Results from single mediation models (Odds Rations (OR) and regression coefficients (B), with 95% confidence intervals (95%CI)) examining potential intrapersonal mediators of leisure time physical activity (> = 150minutes/week)[1] for cross-sectional data at baseline.

Independent variable	Potential mediator	c-path OR (95%CI)[2,8]	a-path B (95%CI)[3,8]	b-path OR (95%CI)[4,8]	c'-path OR (95%CI)[5,8]	Mediated effect a*b (95%CI)[6]	Proportion mediated (a*b)/c[7]
Family social support	Enjoyment	**1.18 (1.11; 1.25)**	**0.64 (0.43; 0.86)**	**1.11 (1.09; 1.13)**	**1.13 (1.06; 1.20)**	**0.07 (0.04;0.09)**	37.5%
	Outcome Expectations	**1.18 (1.11; 1.24)**	**0.14 (0.07; 0.23)**	**1.09 (1.05; 1.13)**	**1.16 (1.10; 1,23)**	0.01 (0.00;0.02))	7.8%
	Self-Efficacy	**1.18 (1.11; 1.25)**	**0.32 (0.20; 0.43)**	**1.22 (1.19; 1.26)**	**1.13 (1.06; 1.21)**	**0.06 (0.04;0.09)**	35.9%
Friend social support	Enjoyment	**1.25 (1.18; 1.33)**	**0.66 (0.51; 0.82)**	**1.11 (1.08; 1.13)**	**1.20 (1.12; 1.28)**	**0.07 (0.05;0.09)**	28.3%
	Outcome Expectations	**1.25 (1.18; 1.32)**	**0.15 (0.06; 0.24)**	**1.09 (1.05; 1.13)**	**1.24 (1.17; 1.32)**	**0.01 (0.00;0.02)**	5.9%
	Self-Efficacy	**1.25 (1.18; 1.33)**	**0.40 (0.30; 0.50)**	**1.22 (1.18; 1.25)**	**1.20 (1.13; 1.28)**	**0.08 (0.05;0.10)**	31.5%

Note. Values represented in bold are significant associations

[1] The dependent variable leisure time physical activity was dichotomized at 150 minutes activity per week

[2] c-path (total effect): is the association of social support from family or friends and leisure time physical activity analysed with a logistic regression analyses

[3] a-path: the association between social support from family or friends and mediator analysed with a linear regression analyses

[4] b-path: the association of mediator and leisure time physical activity analysed with a logistic regression analyses

[5] c'-path (direct effect) is the association of social support from family or friends and leisure time physical activity adjusted for the mediator. This association is analysed with a logistic regression analyses.

[6] Mediated effect (a*b) is the indirect effect of the independent variable on the outcome variable through the potential mediator.

[7] Proportion mediated effect (a*b/c) using the adjusted c coefficient

[8] All analyses are models adjusted for educational level (high, medium, low), living with children (yes, no), living area (rural vs urban) and robust standard errors were used to account for potential clustering within the neighbourhoods

intrapersonal factors was partly supported. Cross-sectional analyses indicated that all intrapersonal factors (PA enjoyment, outcome expectations, self-efficacy) were significant mediators in the associations of social support from family and from friends with LTPA. However, longitudinal analyses did not support the hypothesis that changes in social support from family or from friends and subsequent changes in LTPA, were mediated by changes in PA enjoyment, outcome expectations, or self-efficacy.

Cross-sectional analyses indicated that self-efficacy was a mediator of the associations of social support from family and from friends and LTPA, which is in line with previous studies. [22, 26, 39] A prior study in undergraduate students, for example, demonstrated that the association of social support from friends with PA was fully mediated by self-efficacy, using baseline and three-week follow-up data. [22] Furthermore, a study among adults aged 18–92 supported the hypotheses that the association of social support with PA was mediated by self-efficacy. [39] Additionally, Aghdam et al[26] reported that social support directly and indirectly through self-efficacy affected moderate and vigorous PA in Iranian women aged 36.8 years on average. Thus, results from previous studies and from this study indicate that social support from family or from friends—such as encouragement or co-participation—are associated with an increase in PA partly because levels of self-efficacy increase as well. A plausible explanation may be that family or friends provide verbal encouragement, persuasion and also provide vicarious experiences. Both verbal persuasion and vicarious experience are seen as social influences and are known sources of self-efficacy. [19]

Cross-sectional analyses indicated that enjoyment was a mediator of the associations of social support from family and from friends and LTPA, To our knowledge, ours is the first study that examined the mediating effect of PA enjoyment in the association of social support

Table 4. Results from longitudinal single mediation models (regression coefficients (B) and 95% confidence intervals (95%CI)) examining potential intrapersonal mediators of leisure time physical activity using residual change scores.

Independent variable	Potential mediator	c-path B (95%CI)[1,7]	a-path B (95%CI)[2,7]	b-path B (95%CI)[3,7]	c'-path B (95%CI)[4,7]	Mediated effect a*b (95%CI)[5]	Proportion mediated (a*b)/c[6]
Family social support	Enjoyment	-4.06 (-16.68; 8.57)	0.28 (-.05; 0.60)	-3.00 (-1.25; 7.24)	-4.88 (-17.11; 7.35)	0.82 (-0.86; 2.51)	-
	Outcome Expectations	-3.90 (-16.00; 8.20)	**0.21 (0.04; 0.37)**	6.39 (-4.01; 16.79)	-5.21 (-17.98; 7.55)	1.31 (-1.11; 3.73)	-
	Self-Efficacy	-3.29 (-15.50; 8.92)	0.15 (-0.08; 0.39)	0.39 (-9.42; 10.20)	-3.35 (-15.36; 8.67)	0.06 (-1.82; 1.94)	-
Friend social support	Enjoyment	-7.91 (-21.98; 6.16)	0.28 (-0.01; 0.57)	3.33 (-0.93; 7.59)	-8.83 (-22.27; 4.61)	0.92 (-0.74; 2.58)	-
	Outcome Expectations	-8.42 (-22.32; 5.47)	0.09 (-0.10; 0.28)	6.61 (-3.28; 16.49)	-9.03 (-23.346; 5.19)	0.60 (-1.06; 2.26)	-
	Self-Efficacy	-8.02 (-22.11; 6.07)	**0.30 (0.08; 0.52)**	1.16 (-8.54; 10.86)	-8.37 (-21.95; 5.21)	0.35 (-2.60; 3.30)	-

Note. Values represented in bold are significant associations

[1] c-path (total effect): is the association of changes in social support from family or friends between baseline and 3 year follow-up and changes in leisure time physical activity between 3 year and 5 year follow-up analysed with a linear regression analyses using residual change scores

[2] a-path: the association between changes in social support from family or friends between baseline and 3 year follow-up and changes in the mediator between baseline and 3 year follow-up analysed with a linear regression analyses using residual change scores

[3] b-path: the association of changes in the mediator between baseline and 3 year follow-up and changes in leisure time physical activity between 3 year and 5 year follow-up analysed with a linear regression analyses using residual change scores

[4] c'-path (direct effect) is the association of changes in social support from family or friends between baseline and 3 year follow-up and changes in leisure time physical activity between t 3 year and 5 year follow-up adjusted for changes in the mediator between baseline and 3 year follow-up. This association analysed with a linear regression analyses using residual change scores

[5] Mediated effect (a*b) is the indirect effect of the independent variable on the outcome variable through the potential mediator

[6] Proportion mediated effect (a*b/c)

[7] All analyses are models adjusted for educational level (high, medium, low), living with children (yes, no), living area (rural vs urban) and robust standard errors were used to account for potential clustering within the neighbourhoods

from family or from friends and LTPA. However, several studies examined the association between enjoyment and PA and between social support and enjoyment for PA. Motl et al[40] demonstrated that PA enjoyment was directly associated with PA and indirectly associated with PA through self-efficacy in patients with multiple sclerosis indicating the associations might even be more complex. Moreover, previous qualitative studies indicated that PA was influenced by social support and PA enjoyment. [41] Furthermore, Duin et al[42] reported that social support was an important factor for participating in physical activities, and that social events—including being physically active with others—were reasons to engage in physical activities even if participants did not like the sports. Consequently, having family or friends who co-participate in physical activities might increase levels of PA, because levels of enjoyment increase due to the fact that exercising together is a social event, or because of the social interaction. Furthermore, a supportive and encouraging network can be perceived as a form of positive reinforcement [43], that could increase PA enjoyment and consequently increase PA.

Lastly, we hypothesized that a supportive network of family and friends can facilitate LTPA because social support may positively influence the women's outcome expectations of PA. Again, this hypothesis was only supported by the results from the cross-sectional analyses. Such mediation has not been studied before, but previous research examining the association of outcome expectation and PA and the placement of outcome expectation in health models showed mixed results. [44] For example, Anderson et al[39] showed that outcome expectations partly mediated the association of self-efficacy and PA in adults. Furthermore, Ayotte et al[45]

reported that social support was directly and indirectly associated with outcome expectations through self-efficacy and social support was directly and indirectly associated with PA through self-efficacy. These results indicate that more complex mediation models may be in place and this needs further examination.

None of the cross-sectional evidence for mediation was supported by the longitudinal analyses. The first reason for this may be that the cross-sectional analyses merely indicate associations, but not true mediation. However, the longitudinal analyses also have their limitations, and these are not per definition superior to the cross-sectional analyses in the present study. One issue is that we used change scores for the longitudinal analyses, and that the changes over time were not substantial enough to identify mediated pathways. Additionally, it is not clear what the ideal time laps is for assessing change in determinants and potential mediators –factors like enjoyment, self-efficacy, outcome expectations and perceived social support may have changed repeatedly as well as back and forth between baseline and first follow-up, and this may have obscured predictive and mediation effects over the longer period of time as used for the analyses in the present study. To further investigate the mediators hypothesized in the present study and to strengthen the evidence for causality, intervention studies that induce changes in self-efficacy, PA enjoyment and outcome expectations are needed, with repeated and frequent assessments of both mediators and outcomes. Mediation analyses aim to examine causal pathways and thus mediation models assume specific temporal ordering of the variables. In cross-sectional analyses the presumed time ordering among the variables is based on theory and previous findings; all variables are measured at the same moment and therefore cross-sectional analyses can only estimate the associations based on differences between individuals. Longitudinal analyses have the ability to identify temporal effects and examine the changes within individuals in addition to differences between individuals. [36, 46] Furthermore, previous studies indicate that the associations may be more complex than those tested here. Therefore, studies using alternative modelling approaches such as structural equation modelling are warranted to test more complex models of hypothetical causal pathways.

This study recruited women living in disadvantaged neighbourhoods, a population typically considered 'hard' to reach. [29] Further strengths included the longitudinal design and the use of cross-sectional and longitudinal analyses to test theory-based hypothesis. A limitation is the high attrition rate; however, those who withdrew from the study did not differ from those who remained in the study except for their age and region of residence. Further limitations include the use of single mediation models and the relatively long time intervals between the three measurements.

Conclusion

Results from the cross-sectional analyses provides some evidence that the associations of social support from family and friends and LTPA are mediated by intrapersonal factors, i.e. PA enjoyment, outcome expectations and self-efficacy. However, longitudinal analyses did not confirm this. Future research is needed to determine whether providing or promoting a social supportive network might facilitate LTPA through increases in women's self-efficacy, PA enjoyment and outcome expectations.

Supporting information

S1 Table. Summary of measures of social support and personal factors.
[1] For this sample the Cronbach's alphas were calculated for each of the three measurements (T0-T2)

[2] Abbreviations: k = Cohen's kappa coefficient, ICC = intra class correlation coefficient, assessed in an independent sample of 75 women who administered the survey measures twice, a week apart. [25]

[3] NA = Not applicable, this variable is a sum score of two items

(DOCX)

S2 Table. Baseline characteristics of responders and non-responders.

Note. Responders are those who participated in all three measurements T0, T1 andT2, whereas non-responders are those who only completed the baseline questionnaire (T0). T-test's and chi-square tests were conducted to compare both groups. Means and standard deviations (sd) or number of participants (N) and proportions (%) are presented for both groups with p-values.

[1] Low = did not complete high school, Medium = completed high school/trade certificate/ diploma, High = completed tertiary education

(DOCX)

Author Contributions

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Investigation: KB AT.

Methodology: AM StV JB GA KB.

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References

1. Spring B, Moller AC, Colangelo LA, Siddique J, Roehrig M, Daviglus ML, et al. Healthy lifestyle change and subclinical atherosclerosis in young adults: Coronary Artery Risk Development in Young Adults (CARDIA) study. Circulation 2014 Jul 1; 130(1):10–7. https://doi.org/10.1161/CIRCULATIONAHA.113.005445 PMID: 24982115

2. World Health Organization. Global health risks: mortality and burden of disease attributable to selected major risks. 1–70. 2009. Geneva, Switzerland, WHO Press. 24-7-2012.

3. Schoenborn CA, Stommel M. Adherence to the 2008 adult physical activity guidelines and mortality risk. Am J Prev Med 2011 May; 40(5):514–21. https://doi.org/10.1016/j.amepre.2010.12.029 PMID: 21496750

4. Chen Y, Mao Y. Obesity and leisure time physical activity among Canadians. Prev Med 2006 Apr; 42 (4):261–5. https://doi.org/10.1016/j.ypmed.2006.01.006 PMID: 16476475

5. Australian Bureau of Statistics (ABS). Australian Health Survey: Physical Activity, 2011–12. [ABS Catalogue number 4364.0.55.004]. 19-7-2013.

6. Bell S, Lee C. Emerging adulthood and patterns of physical activity among young Australian women. Int J Behav Med 2005; 12(4):227–35. https://doi.org/10.1207/s15327558ijbm1204_3 PMID: 16262541

7. Kwan MY, Cairney J, Faulkner GE, Pullenayegum EE. Physical activity and other health-risk behaviors during the transition into early adulthood: a longitudinal cohort study. Am J Prev Med 2012 Jan; 42 (1):14–20. https://doi.org/10.1016/j.amepre.2011.08.026 PMID: 22176841

8. Dai S, Wang F, Morrison H. Predictors of decreased physical activity level over time among adults: a longitudinal study. Am J Prev Med 2014 Aug; 47(2):123–30. https://doi.org/10.1016/j.amepre.2014.04.003 PMID: 24877993

9. Allender S, Hutchinson L, Foster C. Life-change events and participation in physical activity: a systematic review. Health Promot Int 2008 Jun; 23(2):160–72. https://doi.org/10.1093/heapro/dan012 PMID: 18364364

10. Kavanagh AM, Goller JL, King T, Jolley D, Crawford D, Turrell G. Urban area disadvantage and physical activity: a multilevel study in Melbourne, Australia. J Epidemiol Community Health 2005 Nov; 59 (11):934–40. https://doi.org/10.1136/jech.2005.035931 PMID: 16234420

11. Buchan DS, Ollis S, Thomas NE, Baker JS. Physical activity behaviour: an overview of current and emergent theoretical practices. J Obes 2012; 2012:546459. https://doi.org/10.1155/2012/546459 PMID: 22778918

12. Bandura A. Social cognitive theory: an agentic perspective. Annu Rev Psychol 2001; 52:1–26. https://doi.org/10.1146/annurev.psych.52.1.1 PMID: 11148297

13. Bandura A. Human agency in social cognitive theory. Am Psychol 1989 Sep; 44(9):1175–84. PMID: 2782727

14. Bandura A. Health promotion by social cognitive means. Health Educ Behav 2004 Apr; 31(2):143–64. https://doi.org/10.1177/1090198104263660 PMID: 15090118

15. Sallis JF, Cervero RB, Ascher W, Henderson KA, Kraft MK, Kerr J. An ecological approach to creating active living communities. Annu Rev Public Health 2006; 27:297–322. https://doi.org/10.1146/annurev.publhealth.27.021405.102100 PMID: 16533119

16. McNeill LH, Kreuter MW, Subramanian SV. Social environment and physical activity: a review of concepts and evidence. Soc Sci Med 2006 Aug; 63(4):1011–22. https://doi.org/10.1016/j.socscimed.2006.03.012 PMID: 16650513

17. Giles-Corti B, Donovan RJ. The relative influence of individual, social and physical environment determinants of physical activity. Soc Sci Med 2002 Jun; 54(12):1793–812. PMID: 12113436

18. Bauman AE, Reis RS, Sallis JF, Wells JC, Loos RJ, Martin BW. Correlates of physical activity: why are some people physically active and others not? Lancet 2012 Jul 21; 380(9838):258–71. https://doi.org/10.1016/S0140-6736(12)60735-1 PMID: 22818938

19. Bandura A. Self-efficacy: toward a unifying theory of behavioral change. Psychol Rev 1977 Mar; 84 (2):191–215. PMID: 847061

20. Winters ER, Petosa RL, Charlton TE. Using social cognitive theory to explain discretionary, "leisure-time" physical exercise among high school students. J Adolesc Health 2003 Jun; 32(6):436–42. PMID: 12782455

21. Kilpatrick M, Hebert E, Bartholomew J. College students' motivation for physical activity: differentiating men's and women's motives for sport participation and exercise. J Am Coll Health 2005 Sep; 54(2): 87–94. https://doi.org/10.3200/JACH.54.2.87-94 PMID: 16255320

22. Rovniak LS, Anderson ES, Winett RA, Stephens RS. Social cognitive determinants of physical activity in young adults: a prospective structural equation analysis. Ann Behav Med 2002; 24(2):149–56. PMID: 12054320

23. Bauman AE, Sallis JF, Dzewaltowski DA, Owen N. Toward a better understanding of the influences on physical activity: the role of determinants, correlates, causal variables, mediators, moderators, and confounders. Am J Prev Med 2002 Aug; 23(2 Suppl):5–14. PMID: 12133733

24. Jeffery RW, Abbott G, Ball K, Crawford D. Behavior and weight correlates of weight-control efforts in Australian women living in disadvantage: The READI study. Int J Behav Nutr Phys Act 2013; 10:52. https://doi.org/10.1186/1479-5868-10-52 PMID: 23621952

25. Ball K, Abbott G, Cleland V, Timperio A, Thornton L, Mishra G, et al. Resilience to obesity among socio-economically disadvantaged women: the READI study. Int J Obes (Lond) 2012 Jun; 36(6):855–65.

26. Bakhtari Aghdam F, Baghiani Moghaddam MH, Asghari Jafarabadi M, Allahverdipour H, Dabagh Nikoo-kheslat S, Noorizadeh R. Explaining the role of personal, social and physical environment factors on employed women's physical activity: a structural equation analysis. Glob J Health Sci 2013 May; 5 (4):189–99. https://doi.org/10.5539/gjhs.v5n4p189 PMID: 23777735

27. McNeill LH, Wyrwich KW, Brownson RC, Clark EM, Kreuter MW. Individual, social environmental, and physical environmental influences on physical activity among black and white adults: a structural equation analysis. Ann Behav Med 2006 Feb; 31(1):36–44. https://doi.org/10.1207/s15324796abm3101_7 PMID: 16472037

28. Maxwell SE, Cole DA. Bias in cross-sectional analyses of longitudinal mediation. Psychol Methods 2007 Mar; 12(1):23–44. https://doi.org/10.1037/1082-989X.12.1.23 PMID: 17402810

29. Ball K, Cleland V, Salmon J, Timperio AF, McNaughton S, Thornton L, et al. Cohort Profile: The Resilience for Eating and Activity Despite Inequality (READI) study. Int J Epidemiol 2012 Dec 18.

30. Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE, et al. International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc 2003 Aug; 35(8): 1381–95. https://doi.org/10.1249/01.MSS.0000078924.61453.FB PMID: 12900694

31. Sallis JF, Grossman RM, Pinski RB, Patterson TL, Nader PR. The development of scales to measure social support for diet and exercise behaviors. Prev Med 1987 Nov; 16(6):825–36. PMID: 3432232

32. Kendzierski D, DeCarlo KJ. Physical Activity Enjoyment Scale: Two validation studies. J Sport Exerc Psychol 1991 Mar; 13(1):50–64.

33. Marcus BH, Selby VC, Niaura RS, Rossi JS. Self-efficacy and the stages of exercise behavior change. Res Q Exerc Sport 1992 Mar; 63(1):60–6. https://doi.org/10.1080/02701367.1992.10607557 PMID: 1574662

34. Mackinnon DP, Fairchild AJ, Fritz MS. Mediation analysis. Annu Rev Psychol 2007; 58:593–614. https://doi.org/10.1146/annurev.psych.58.110405.085542 PMID: 16968208

35. Cerin E, Mackinnon DP. A commentary on current practice in mediating variable analyses in behavioural nutrition and physical activity. Public Health Nutr 2009 Aug; 12(8):1182–8. https://doi.org/10.1017/S1368980008003649 PMID: 18778534

36. Mackinnon DP. Introduction to Statistical Mediation Analysis. 1–488. 2008.

37. Selig JP, Preacher KJ. Mediation Models for Longitudinal Data in Developmental Research. Res Hum Dev 2009 Jun; 6(2–3):144–64.

38. Twisk J, Proper K. Evaluation of the results of a randomized controlled trial: how to define changes between baseline and follow-up. J Clin Epidemiol 2004 Mar; 57(3):223–8. https://doi.org/10.1016/j.jclinepi.2003.07.009 PMID: 15066681

39. Anderson ES, Wojcik JR, Winett RA, Williams DM. Social-cognitive determinants of physical activity: the influence of social support, self-efficacy, outcome expectations, and self-regulation among participants in a church-based health promotion study. Health Psychol 2006 Jul; 25(4):510–20. https://doi.org/10.1037/0278-6133.25.4.510 PMID: 16846326

40. Motl RW, Snook EM, McAuley E, Scott JA, Douglass ML. Correlates of physical activity among individuals with multiple sclerosis. Ann Behav Med 2006 Oct; 32(2):154–61. https://doi.org/10.1207/s15324796abm3202_13 PMID: 16972813

41. Deliens T, Deforche B, De B I, Clarys P. Determinants of physical activity and sedentary behaviour in university students: a qualitative study using focus group discussions. BMC Public Health 2015; 15:201. https://doi.org/10.1186/s12889-015-1553-4 PMID: 25881120

42. Duin DK, Golbeck AL, Keippel AE, Ciemins E, Hanson H, Neary T, et al. Using gender-based analyses to understand physical inactivity among women in Yellowstone County, Montana. Eval Program Plann 2015 Aug; 51:45–52. https://doi.org/10.1016/j.evalprogplan.2014.12.006 PMID: 25542368

43. Gabriele JM, Walker MS, Gill DL, Harber KD, Fisher EB. Differentiated roles of social encouragement and social constraint on physical activity behavior. Ann Behav Med 2005 Jun; 29(3):210–5. https://doi.org/10.1207/s15324796abm2903_7 PMID: 15946115

44. Williams L, Campbell K, Abbott G, Crawford D, Ball K. Is maternal nutrition knowledge more strongly associated with the diets of mothers or their school-aged children? Public Health Nutr 2012 Aug; 15(8):1396–401. https://doi.org/10.1017/S1368980011003430 PMID: 22230490

45. Ayotte BJ, Margrett JA, Hicks-Patrick J. Physical activity in middle-aged and young-old adults: the roles of self-efficacy, barriers, outcome expectancies, self-regulatory behaviors and social support. J Health Psychol 2010 Mar; 15(2):173–85. https://doi.org/10.1177/1359105309342283 PMID: 20207661

46. Lockhart G, MacKinnon DP, Ohlrich V. Mediation analysis in psychosomatic medicine research. Psychosom Med 2011 Jan; 73(1):29–43. https://doi.org/10.1097/PSY.0b013e318200a54b PMID: 21148809