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Beyond emotional benefits: Physical activity and sedentary behaviour affect psychosocial resources through emotions

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Physical activity is known to improve emotional experiences, and positive emotions have been shown to lead to important life outcomes, including the development of psychosocial resources. In contrast, time spent sedentary may negatively impact emotional experiences and, consequently, erode psychosocial resources. Two studies tested whether activity independently influenced emotions and psychosocial resources, and whether activity indirectly influenced psychosocial resources through emotional experiences. Using cross-sectional (Study 1a) and longitudinal (Study 1b) methods, we found that time spent physically active independently predicted emotions and psychosocial resources. Mediation analyses suggested that emotions may account for the relation between activity and psychosocial resources. The improved emotional experiences associated with physical activity may help individuals build psychosocial resources known to improve mental health. Study 1a provided first indicators to suggest that, in contrast, sedentary behaviour may reduce positive emotions, which could in turn lead to decrements in psychosocial resources.

Keywords: physical activity; exercise; sedentary behaviour; positive emotions; psychosocial resources

Just minutes after engaging in physical activity, participants report feeling more positive (e.g. more energy and vigour) (Berger & Motl, 2000; Reed & Ones, 2006 for a meta-analysis), and less negative (e.g. less fatigue and anxiety) (Gauvin, Rejeski, & Norris, 1996; Johansson, Hassmén, & Jouper, 2011; Youngstedt, 2010). These effects have been demonstrated both experimentally, in controlled lab settings, and in daily life, using ecological momentary assessment techniques (e.g. Giacobbi, Hausenblas, & Frye, 2005; Hogan, Mata, & Carstensen, 2013; Mata et al., 2012).

To date, the emotional effects of physical activity have largely been viewed as ends in themselves. For example, physical activity is commonly recommended as part of treatment for those suffering from emotional disorders (Walsh, 2011). Yet, altering emotions can be a means to additional ends. Positive responses to physical activity completed in a laboratory setting have been linked to reports of increased participation up to one year later, suggesting that feeling good after physical activity may promote

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more physical activity over time (e.g. Williams et al., 2008; Williams, Dunsiger, Jennings, & Marcus, 2012). Moreover, positive emotions predict important life outcomes, such as the strength of people's social networks, including the likelihood of getting married in the future (Marks & Fleming, 1999), and the ability to meet the demands of everyday life, such as maintaining employment (Diener, Nickerson, Lucas, & Sandvik, 2002). The broaden-and-build theory of positive emotions suggests that positive emotions cause or help create these outcomes or 'resources' (Fredrickson, 1998, 2013). The theory states that unlike negative emotions, which narrow people's attention and thinking, positive emotions broaden attention and cognitions. Over time, these repeated experiences of broadened cognition help people to discover and build a variety of resources – psychological (e.g. environmental mastery), social (e.g. strong social bonds), cognitive (e.g. creativity) and physical (e.g. heightened immunity from colds) – which ultimately help people navigate successfully through life, but do not themselves directly reflect emotionality (Fredrickson, 1998, 2013). A body of research reveals prospective links between positive emotions and favourable outcomes or resources (for a meta-analysis see Lyubomirsky, King, & Diener, 2005) and longitudinal field experiments provide support for the causal relationship (Fredrickson, Cohn, Coffey, Pek, & Finkel, 2008; Kok et al., 2013). For instance, in one field experiment, participants were assigned to be in a loving-kindness meditation intervention or serve in a wait list control group (Fredrickson et al., 2008). Results revealed that the meditation practice caused increases over time in daily positive emotions, which in turn created increases in resources such as environmental mastery, social support and purpose in life. Drawing on the broaden-and-build theory, we posit that positive emotions resulting from physical activity may also create increases in such resources. We focus on physical activity because it is a behaviour that is accessible to most individuals, requires no special training and in one form or another appeals across strata of society.

In the present research, we examined whether the emotional experiences sparked by physical activity functioned not only as an outcome, but also as a mechanism underlying the relation between physical activity and psychosocial resources. Because physical activity has been linked with lower levels of negative states (e.g. Gauvin et al., 1996; Mata, Hogan, Joormann, Waugh, & Gotlib, 2013), we also tested whether negative emotions also played a mechanistic role in linking activity behaviour to psychosocial resources. In addition, we tested whether sedentary behaviour may negatively impact psychosocial resources through lower levels of positive emotions. Little is known about the effects of sedentary behaviour on feeling states. The few studies available suggest that higher levels of sedentary behaviour, indexed as self-reported daily screen time or daily time spent sitting or lying, may be associated with greater risk for developing depressive symptoms (Teychenne, Ball, & Salmon, 2010). At the surface, effects of sedentary behaviour may seem indistinguishable from lack of physical activity; however, this may not be the case. In the context of physical health, sedentary behaviour and physical activity appear to exert independent effects on risk of disease and mortality: 'Active couch potatoes' (i.e. individuals who exercise regularly, but also spend large amounts of time sedentary) undo the physical benefits of physical activity through their predominantly sedentary lifestyle (Owen, Healy, Matthews, & Dunstan, 2010). It is, therefore, necessary that research examining the potential deleterious effects of sedentary behaviour on feeling states and other psychological outcomes consider such effects controlling for physical activity.

We used both cross-sectional and longitudinal methods to test the relations among physical activity, sedentary behaviour, emotions (positive and negative) and psychosocial resources. Specifically, we hypothesised that (1) time spent in physical activity and sedentary behaviour would independently predict both emotions and psychosocial resources and that (2) activity behaviour would indirectly influence psychosocial resources through emotions. An alternative possibility is that positive emotions lead to increased psychosocial resources through physical activity. Within the broaden-and-build theoretical framework, it is possible that broadened attention and cognition spurred by positive emotions may lead individuals to notice more opportunities to engage in physical activity (e.g. taking stairs instead of elevator, parking further away). Therefore, we also tested this alternative model.

Study 1a

Method

Participants and procedure

Community-dwelling adults were recruited through flyers, emails and Craigslist ads, to participate in an Internet-based survey. This survey was used as part of a screening to participate in Study 1b (see description below). Participants ($N = 624$) aged 19–65 years completed all relevant measures in exchange for $20. Participant characteristics are presented in Table 1 and intercorrelations are presented in Table 2. All study procedures were approved by the Institutional Review Board of The University of North Carolina at Chapel Hill.

Measures

Physical activity and sedentary behaviour

We assessed participants' physical activity and sedentary behaviour with the short version of the international physical activity questionnaire (IPAQ; www.ipaq.ki.se). Previous research has found that scores from both long and short versions of this measure are equally valid and reliable (Craig et al., 2003). This measure consists of seven items. Participants are asked to report how many times during the previous seven days

Table 1. Summary of demographic characteristics, emotions, psychosocial resources and activity variables in Study 1a and Study 1b.

Variable	Study 1a ($N = 624$)	Study 1b ($N = 178$)
Age; *M* (SD)	40.9 (9.6)	41.4 (9.8)
Gender (% female)	53.7	60.1
Ethnicity (% non-white)	25	15.2
Education (% college graduates)	55.9	59.6
Positive emotions; *M* (SD)	3.32 (.86)	2.32 (.76)
Negative emotions; *M* (SD)	1.99 (.78)	1.15 (.19)
Psychosocial resources; *M* (SD)	4.11 (.95)	4.19 (1.00)
Physical activity (minutes/day); median, range	51.4, 0–488.6	65, 0–1020
Sedentary behaviour (minutes/day); median, range	360, 0–1440	–

Note: Psychosocial resource data were collected at follow-up for Study 1b ($N = 142$).

Table 2. Summary of intercorrelations for demographic characteristics, emotions, psychosocial resources and activity variables in Study 1a and Study 1b.

Variable	1	2	3	4	5	6	7	8	9
1. Positive emotions	–	−.44**	.74**	.22**	−.15**	.03	.03	.13**	.01
2. Negative emotions	−.06	–	−.48**	−.13**	.06	−.19**	−.04	.03	.03
3. Psychosocial resources	.44**	−.20**	–	.19**	−.13**	.08	.01	.06	.07
4. Physical activity	.33**	−.10	.24**	–	−.16**	−.02	−.15**	−.02	−.16**
5. Sedentary behaviour	–	–	–	–	–	.02	.07	−.01	.06
6. Age	.15*	−.03	.06	.18*	–	–	.07	−.17**	−.07
7. Sex	.02	.01	.13	−.02	–	.06	–	−.08	−.03
8. Ethnicity	.13	.07	−.05	.08	–	−.06	.05	–	.06
9. Education	−.09	.07	.06	−.04	–	.01	−.02	−.01	–

Note: Intercorrelations for Study 1a are presented above the diagonal, and intercorrelations for Study 1b are presented below the diagonal. Raw scores were used for the correlations presented above; however, significance level remains unchanged if transformed, Winsorized variables are substituted.
*$p < .05$; **$p < .01$.

(i.e. number of sessions) and how much time per session (i.e. session duration) they engaged in walking, moderate (e.g. carrying light loads, doubles tennis) and vigorous activity (e.g. aerobics, fast bicycling). Participants also indicated how much time per day they spent sitting.

Emotions

We assessed frequency of positive and negative emotions experienced during the preceding two weeks using the modified Differential Emotions Scale (mDES; Fredrickson, 2013). Participants rated nine positive (amusement, awe, contentment, gratitude, hope, interest, joy, love and pride) and 10 negative emotions (anger, shame, contempt, disgust, embarrassment, guilt, hate, sadness, fear and stress) on a five-point scale (1 = *not at all*, 2 = *a little bit*, 3 = *some of the time*, 4 = *often*, 5 = *most of the time*). We calculated composite scores for positive ($\alpha = .95$) and negative ($\alpha = .93$) emotions by averaging across emotions in those two categories.

Psychosocial resources

We assessed psychosocial resources using a subset of items from the mental health continuum – short form (MHC-SF; Keyes, 2009). Specifically, we selected the 11 eudaimonic items of the MHC-SF, and excluded the three hedonic items. The 11 eudaimonic items target self-acceptance, environmental mastery, purpose in life, positive relations with others, autonomy, personal growth, social contribution, social actualisation, social coherence, social acceptance and social integration. Previous research has shown scores from this measure to be highly reliable and as showing construct validity (Keyes et al., 2008; Lamers, Westerhof, ten Klooster, & Keyes, 2011). Participants indicated agreement or disagreement on a six-point scale (1 = *never*, 2 = *once or twice*, 3 = *about once*

a week, 4 = *two or three times a week*, 5 = *almost every day* 6 = *every day*; α = .93) to items such as 'In the past month, how often did you feel good at managing the responsibilities of your daily life?' (environmental mastery) and 'In the past month, how often did you feel that you belonged to a community (like a social group, or your neighborhood)?' (social integration). Following the precedent of Fredrickson et al. (2008), we conceptualise responses to these items as reflecting participants' degrees of psychosocial resources.

Data analyses

IBM SPSS version 20 was used for data analysis. In accordance with standard guidelines, IPAQ session duration values of less than 10 min were recoded to zero, and walking, moderate and vigorous time variables exceeding 180 min were truncated to 180 min (Craig et al., 2003; www.ipaq.ki.se/scoring.htm). Time spent at each intensity level of physical activity (i.e. walking, moderate, vigorous) was calculated as the product of minutes per activity bout by bouts per week. Total physical activity (total physical activity minutes) was calculated as the sum of these values for walking, moderate and vigorous activity. Sedentary behaviour was calculated as total minutes spent sitting each week, in accord with evidence that sitting is a key feature of sedentary behaviour (Sedentary Behavior Research Network, 2012). Cases with missing or ambiguous IPAQ values (e.g. responses of 'don't know' or 'not sure') were excluded from analyses ($N = 75$). Positive emotions and negative emotions data were missing from nine participants, and psychosocial resource data were missing for one participant; however, these cases were already excluded due to missing IPAQ data. Skewed variables were square root transformed prior to analyses and outlier values were Winsorized to the 95th percentile values. Means and standard deviations for positive emotions, negative emotions, psychosocial resources, physical activity and sedentary behaviour are presented in Table 1.

To test Hypothesis 1 (i.e. time spent in physical activity and time spent sedentary independently influence both emotional experiences and psychosocial resources), positive emotions, negative emotions and psychosocial resources were each regressed on total physical activity and sedentary behaviour. Standardised regression coefficients (β) are presented. All data met assumptions for regression analyses.

We tested Hypothesis 2 (i.e. activity behaviour affects psychosocial resources through experienced emotions) using a bootstrapping approach with the PROCESS procedure for SPSS and SAS (Hayes, 2013). We constructed 95% confidence intervals (CI) with a resampling size of 5000 (Hayes, 2013; Preacher & Hayes, 2004). Recent research suggests that this approach offers several advantages over the traditional Baron and Kenny (1986) method of assessing mediation because it offers improved statistical power, does not rely on assumptions about the shape of the distribution of indirect effect and facilitates testing and comparing multiple mediators within the same model (Hayes, 2009; Preacher & Hayes, 2008). To test whether the unique contribution of each proposed intervening (mediator) variable (i.e. positive emotions and negative emotions) was significantly different from zero, psychosocial resources were entered into the bootstrap model as the dependent variable with total physical activity as independent variable, sedentary minutes as covariate and positive emotions and negative emotions as proposed intervening variables (mediators). To test the significance of the

indirect effect of positive emotions and negative emotions on the link between sedentary behaviour and psychosocial resources, psychosocial resources were the dependent variable, sedentary minutes the independent variable, total physical activity a covariate and positive emotions and negative emotions as mediators. Bias-corrected CI are presented because this method of generating CI is thought to correct for both bias and skewness in the bootstrap distribution (Efron, 1987; Efron & Tibshirani, 1993). CI that do not cross zero indicate the presence of a significant indirect effect. The alpha level was set at .05 for all analyses. Effect sizes for indirect effects are presented as kappa squared (K^2; Preacher & Kelley, 2011).

To examine the directionality of the relation between physical activity (and sedentary behaviour) and emotions in these cross-sectional data, we tested two additional models, also using the bootstrap approach. In the first model, psychosocial resources were entered into the model as the dependent variable with positive emotions as independent variable, negative emotions as covariate and physical activity and sedentary behaviour as proposed intervening variables (mediators). The second model was identical except negative emotions were entered as the independent variable and positive emotions as a covariate.

Results and discussion

Results supported Hypothesis 1: Physical activity, controlling for sedentary behaviour, predicted more frequent positive emotions ($\beta = .27$, $p < .001$, $R^2 = .10$), less frequent negative emotions ($\beta = -.18$, $p < .001$, $R^2 = .03$) and more psychosocial resources ($\beta = .23$, $p < .001$, $R^2 = .07$). In contrast, sedentary behaviour, controlling for physical activity, predicted less frequent positive emotions ($\beta = -.11$, $p = .008$, $R^2 = .10$) and fewer psychosocial resources ($\beta = -.11$, $p = .012$, $R^2 = .07$). Sedentary behaviour, controlling for physical activity, did not predict negative emotions ($\beta = .001$, *ns*).

Supporting Hypothesis 2 (i.e. total physical activity and sedentary behaviour are associated with psychosocial resources through their effects on emotions), bias-corrected (BC) 95% CI showed a significant indirect effect between total physical activity and psychosocial resources, carried by both positive emotions (medium-sized effect; $K^2 = .1846$, 95% CI = .1305–.2369) and negative emotions (small-sized effect; $K^2 = .0372$, 95% CI = .0174–.0655). Point estimates and CIs are presented in Table 3. The total indirect effect (i.e. the combined indirect effect of positive and negative emotions) was significantly different from zero, and the specific indirect effects (i.e. the specific effect of positive emotions and the specific effect of negative emotions, respectively) were also significantly different from zero. This suggests that physical activity participation has an indirect effect on psychosocial resources through both positive emotions and negative emotions, controlling for sedentary behaviour. The direction of the *a* path for positive emotions (i.e. the relation between physical activity and positive emotions; $\beta = .27$, $p < .001$) and the *b* path for positive emotions (i.e. the relation between positive emotions and psychosocial resources; $\beta = .74$, $p < .001$) are consistent with the interpretation that higher physical activity levels are associated with higher levels of positive emotions, and higher levels of positive emotions are associated with greater psychosocial resources. Furthermore, the direction of the *a* path for negative emotions (i.e. the relation between physical activity and negative emotions; $\beta = -.18$, $p < .001$) and the *b* path for negative emotions (i.e. the relation between negative

Table 3. Testing the indirect effects of positive emotions and negative emotions on the relation between physical activity and sedentary behaviour on psychological resources using the bootstrapping approach in Study 1a and Study 1b.

		Total indirect effect			Specific indirect effect: positive emotion			Specific indirect effect: negative emotion		
			95% confidence interval			95% confidence interval			95% confidence interval	
	Independent variable	Point estimate	Lower limit	Upper limit	Point estimate	Lower limit	Upper limit	Point estimate	Lower limit	Upper limit
Study 1a	Physical activity	***.0170***	***.0113***	***.0224***	***.0145***	***.0096***	***.0196***	***.0027***	***.0013***	***.0043***
	Sedentary behaviour	***−.0044***	***−.0081***	***−.0005***	***−.0046***	***−.0084***	***−.0009***	.0000	−.0009	.0010
Study 1b	Physical activity	***.0667***	***.0183***	***.1431***	***.0580***	***.0133***	***.1317***	.0087	−.0046	.0455

Note: CI (bias corrected) are based on 5000 bootstrap samples. Indirect effects are significant when zero is not included in the CI, as indicated here by bold italics.

emotions and psychosocial resources; $\beta = -.49$, $p < .001$) are consistent with the interpretation that higher physical activity levels are associated with lower levels of negative emotions, and lower levels of negative emotions are associated with greater psychosocial resources. Contrasts comparing the indirect effects of positive and negative emotions showed that the specific indirect effect of positive emotions was larger than the specific indirect effect of negative emotions with a point estimate of .0117 (BC 95% CI .0071–.0166). This indicates that the contribution of positive emotions to the indirect effect of physical activity on psychosocial resources was significantly larger than that of negative emotions.

Also in support of Hypothesis 2, we observed a medium-sized ($K^2 = .1407$, 95% CI = .0687–.2116) significant indirect effect between sedentary minutes and psychosocial resources, controlling for physical activity, carried by positive emotions, with a specific indirect point estimate that differed significantly from zero (point estimate and CI presented in Table 3). This suggests that sedentary behaviour had an indirect effect on psychosocial resources through positive emotions, controlling for physical activity. The direction of the *a* path for positive emotions (i.e. the relation between sedentary behaviour and positive emotions; $\beta = -.11$, $p = .008$) and the *b* path for positive emotions (i.e. the relation between positive emotions and psychosocial resources; $\beta = .74$, $p < .001$) are consistent with the interpretation that, independent of a person's physical activity, the higher their sedentary behaviour, the lower their levels of positive emotions, and the lower their levels of positive emotions, the lower their levels of psychosocial resources. No significant indirect effect of negative emotions on the relation between sedentary minutes and psychosocial resources was observed.

Results did not support the alternative directionality models. We did not observe a significant indirect effect of either physical activity (95% CI = −.0094 to .0249) or sedentary behaviour (95% CI = −.0043 to .0213) on the relation between positive emotions and psychosocial resources. We also did not observe a significant indirect effect of either physical activity (95% CI = −.0123 to .0016) or sedentary behaviour (95% CI = −.0014 to .0125) on the relation between negative emotions and psychosocial resources.

Taken together, these findings are consistent with the idea that, beyond their hedonic value, the emotional benefits of physical activity may carry added value as means to build psychosocial resources. These data are also consistent with the hypothesis that sedentary behaviour dampens positive emotions, which may lead to an erosion of psychosocial resources. Interpretation of these results, however, is limited due to the cross-sectional nature of the data, which cannot support definitive causal claims. In addition, the measures used in Study 1a relied on participants' ability to remember their physical activity, sedentary behaviour and emotions over sizeable amounts of time (e.g. a week). To remedy potential retrospective bias in Study 1a and employ a more granular focus, we used the day reconstruction method (DRM) in Study 1b. The DRM asks participants to reflect upon the previous day, create a diary of their day from waking up to going to sleep and then answer questions (e.g. activities, emotions) regarding each 'episode' of their day. With the specifics of the previous day cued, reporting biases are minimised (Kahneman, Krueger, Schkade, Schwarz, & Stone, 2004). Therefore, in Study 1b, we tested the same hypotheses as in Study 1a, using the DRM, nested within a longitudinal design.

Study 1b

Method

Participants and procedure

A subset[1] of participants ($N = 208$) from Study 1a was recontacted to complete a web-based version of the DRM (Kahneman et al., 2004). Participant characteristics are shown in Table 1. Participants received $50. Approximately three months later, 142 participants completed follow-up questionnaires in exchange for $20. All study procedures were approved by the Institutional Review Board of The University of North Carolina at Chapel Hill.

Measures

Day reconstruction method (DRM)

The DRM is a tool that provides an in-depth look at a day in the life of an individual (Kahneman et al., 2004). With this measure, detailed accounts of participants' activities and emotions across a single Tuesday (a day likely to be characteristic of typical day-to-day life) were captured on a Wednesday morning (Catalino & Fredrickson, 2011). Participants were asked to reflect upon the previous day and divide it into a series of episodes, and report the time each episode started and ended. Episodes were described to participants as lasting between 15 min to 2 h and indications of the end of an episode might include going to a different location, ending one activity and starting another, or a change in one's company. After creating a contiguous set of episodes to reflect their Tuesday, for each episode, participants next endorsed the activities (e.g. physical activity) in which they engaged, and rated the emotions they experienced. Mention of physical activity or sedentary behaviour did not occur elsewhere in the survey.

Physical activity. Participants' representative levels of physical activity were assessed using the DRM. For each episode, we asked participants to what degree they were physically active on a five-point scale (1 = *not at all,* 2 = *a little bit*, 3 = *somewhat*, 4 = *moderately*, 5 = *very much so*). To index time spent being physically active, we totalled the duration of all episodes in which participants reported doing something physically active at a '4' (*moderately*) or above.

Emotions. Participants' representative emotions were also assessed using the DRM. We asked participants about the positive and negative emotions experienced during each episode using a variant of the mDES (as described for Study 1a) in which participants were asked to rate the intensity of emotions (rather than the frequency) on a five-point scale (1 = *not at all*, 2 = *a little bit*, 3 = *somewhat*, 4 = *moderately*, 5 = *extremely*). We calculated composite scores for positive ($\alpha = .95$) and for negative ($\alpha = .85$) emotions by averaging across emotions in those two categories across all episodes for that day. By assessing emotional intensity across multiple time points, this measure of emotion captures both frequency and intensity aspects of emotional experiences.

Psychosocial resources

Approximately three months after completing the web-based DRM, participants completed questionnaires online. As in Study 1a, psychosocial resources were assessed using the designated 11 items of the MHC-SF (Keyes, 2009).

Data analyses

Consistent with Study 1a procedures, skewed variables were square root transformed prior to analyses and outlier values were Winsorized to the 95th percentile values. Means and standard deviations are shown in Table 1 and intercorrelations are shown in Table 2. We tested whether time spent in physical activity influenced both emotional experiences and psychosocial resources using linear regressions in which positive emotions, negative emotions and psychosocial resources were each regressed on physical activity. We tested whether time spent being physically active on a representative day predicted future psychosocial resources through its effects on positive emotions that day using identical bootstrapping procedures as those described for Study 1a. We included initial psychosocial resources as a covariate in these analyses.[2]

To examine the directionality of the relation between physical activity and emotions in these data, as in Study 1a, we tested two additional models using the bootstrap approach: one in which positive emotions were entered as the independent variable (with negative emotions as a covariate) and one in which negative emotions were entered as the independent variable (with positive emotions as a covariate). For both models, physical activity was entered as the proposed mediator, psychosocial resources were the dependent variable and initial resources were included as a covariate. In addition, we examined directionality between physical activity and emotion by analysing these data from a within-person approach, using multilevel modelling. Specifically, we examined within-person changes in emotions as a function of physical activity across DRM episodes using the mixed models function in SPSS. We separated physical activity values into two components: a person-level average across episodes (between-person component) and a person-centred episode score (episode-level deviations in physical activity; within-person component) (Schwartz & Stone, 1998). We created a single-episode lagged variable for positive emotions and for negative emotions to reflect positive emotions level and negative emotions level in the previous episode. We included previous episode emotions as covariates in the models tested to assess change in emotion with physical activity within an episode. Two models were fit with maximum likelihood estimation: one for positive emotions and one for negative emotions. In the Level-1 model, episode-level emotion was regressed on episode, deviations in physical activity and previous-episode emotion. In the Level-2 model, the intercept for emotions was regressed on overall physical activity.

Results and discussion

In support of Hypothesis 1, time spent being physically active on the assessed Tuesday predicted significantly more intense positive emotions ($\beta = .32$, $p < .001$, $R^2 = .10$) and more psychosocial resources months later ($\beta = .17$, $p = .013$, $R^2 = .37$), controlling for initial psychosocial resources. We did not observe a significant association between physical activity and negative emotions on the assessed Tuesday ($p = .114$).

In support of Hypothesis 2, we observed a significant indirect effect of time spent physically active on a Tuesday on increases in psychosocial resources through positive emotions (medium-sized effect; $K^2 = .0544$, 95% CI = .0114–.1287). The directions of the *a* path (i.e. the relation between physical activity and positive emotions; $\beta = .32$, $p < .001$) and the *b* path (i.e. the relation between positive emotions and psychosocial resources; $\beta = .43$, $p < .001$) were consistent with the interpretation that higher physical activity levels may lead to higher levels of positive emotions, which, in turn, may lead to increases in psychosocial resources. We did not observe a significant indirect effect of negative emotions on the relation between physical activity and psychosocial resources. Point estimates and CI are provided in Table 3.

Results did not support the alternative directionality models: we failed to observe a significant indirect effect of physical activity on the relation between positive emotions and psychosocial resources (95% CI = −.0064 to .1343) or the relation between negative emotions and psychosocial resources (95% CI = −.7048 to .0659).

Results of the within-person analyses are consistent with the interpretation that within episodes in which participants were more active than their average across the day, they reported increased positive emotions ($\gamma = .002$, SE = .0005, $p < .001$). We did not observe an association between changes in negative emotions and deviations in physical activity across episodes ($p = .259$).

Discussion

The purpose of the current research was to examine whether emotional experiences emerge not only as a result of physical activity, but additionally, function as a mechanism underlying the relation between physical activity and psychosocial resources, such as positive relations with others, sense of purpose and meaning and a sense of contribution to society.

Associations among activity, emotions and psychosocial resources

Findings from the current research generally supported Hypothesis 1: That is, time spent in physical activity and time spent sedentary are independently associated with both emotional experiences and psychosocial resources. In Study 1a, we observed cross-sectional evidence for a relation between physical activity and positive emotions and between physical activity and negative emotions, replicating findings from previous research which have linked physical activity with more positive and less negative emotional experiences (e.g. Mata et al., 2013; Reed & Ones, 2006). In Study 1b, we again observed a link between physical activity and positive emotions. We did not observe a significant association between physical activity and negative emotions in Study 1b; however, participants reported very low levels of and low variability in negative states in this study, which may account for the lack of association.

Results of Study 1a provide cross-sectional evidence for the relation between physical activity and psychosocial resources, supporting previous research that has linked physical activity with other resources such as self-efficacy and creativity (Focht, Knapp, Gavin, Raedeke, & Hickner, 2007; Steinberg et al., 1997). Results from Study 1b extend previous work by linking physical activity on a typical day with gains in psychosocial resources about three months later.

Results from Study 1a also suggest that the effects of sedentary behaviour may be less desirable. As predicted in Study 1a, sedentary behaviour was cross-sectionally associated with less frequent positive emotions and fewer psychosocial resources. To the best of our knowledge, this is the first study to link sedentary behaviour to emotions and psychosocial resources, and our findings hint at the psychological price individuals may pay due to the sedentary nature of modern life. An important step for future research will be to continue to identify the consequences of sedentary behaviour on emotional experiences and indicators of psychological health such as psychosocial resources, and to work to clarify distinctions between the effects of physical activity vs. the effects of sedentary behaviour.

Activity behaviour effects on psychosocial resources through emotions

Drawing on Fredrickson's broaden-and-build theory of positive emotions (1998, 2013), Hypothesis 2 predicted that activity behaviour affects psychosocial resources through experienced emotions. Study 1a provided cross-sectional support for this hypothesis. We observed a significant indirect effect indicating that physical activity is associated with psychosocial resources through experienced emotions. More frequent positive and less frequent negative emotions each accounted for a significant portion of the indirect effect of physical activity on psychosocial resources. We also observed that the indirect effect of positive emotions was stronger than the indirect effect of negative emotions, which may suggest that increased positive feelings from physical activity may play a larger role in the relation between physical activity and psychosocial resources than decreased negative emotions. In Study 1b, we found that physical activity during a typical weekday predicted increases in psychosocial resources about three months later through positive emotions during that day. The affective benefits of participation in physical activity have been widely recognised, yet physical activity may do more psychologically than simply make individuals 'feel better' (i.e. experiencing more positive and fewer negative emotions). These findings provide initial evidence that the improved emotional experiences associated with physical activity may also help individuals build psychosocial resources, such as a greater sense of purpose and meaning, and a sense of contribution to society, all of which, in turn, could foster a sense of well-being for the individual and the community. Taken together, these findings emphasise the enduring value of the emotional benefits individuals may experience from being physically active by suggesting that, much as we can strengthen our cardiovascular system and reduce our risk of heart disease, we may also be able to strengthen our levels of key psychosocial resources by being physically active.

Results from Study 1a also suggested that sedentary behaviour has an indirect effect on psychosocial resources through positive emotions. Although this evidence is preliminary, it suggests that sedentary behaviour may be an important target for future researchers when designing studies or interventions aimed at influencing emotions and psychosocial resources.

To test for a potential bidirectional effect, we also examined whether positive and negative emotions might be linked to psychosocial resources through activity behaviour. Results, however, did not support this alternative model for Study 1a or for Study 1b. In addition, we observed in Study 1b that within-person changes in physical activity

were associated with increases in positive emotions, which provided further support for the hypothesised directionality of the link between physical activity and psychosocial resources through positive emotions.

Theoretical and practical implications

There are several theoretical and practical implications of this research. The current studies help characterise the psychological effects of sedentary behaviour and provide initial evidence that sedentary behaviour may impact psychosocial resources and thereby mental health. Additionally, although the relation between physical activity and improved affect has been demonstrated, previous research has not addressed the potential consequences of these effects, and findings from the current research suggest that these effects may lead to gains in psychosocial resources and thereby mental health. Our findings also provide further support for Fredrickson's broaden-and-build theory of positive emotions by suggesting that increased experiences of positive emotions, gained through physical activity, lead to gains in psychosocial resources.

Strengths and limitations

The relatively large sample of individuals drawn from the community represents a strength of this study and may enhance the generalisability of our findings. In addition, because the Preacher and Hayes (2004) bootstrap approach to mediation analyses offers several advantages over the traditional Baron and Kenny (1986) approach, employment of this statistical method represents a second strength of the current research. Use of the DRM and multilevel modelling analyses also represent methodological strengths of the current research. An important limitation of this research is the lack of objective measurement of physical activity and sedentary behaviour. The current findings based on self-report measures of physical activity and sedentary behaviour should be replicated in designs that combine more objective methods, such as actigraphy, with self-report.

Summary and conclusion

Although further evidence is required to better understand the full impact of people's physical activity and sedentary behaviour, the consequences of physical activity paint a picture of personal growth and well-being (i.e. greater psychosocial resources, as observed in Study 1a and 1b), whereas sedentary behaviour conjures an image of stagnation (i.e. fewer psychosocial resources, as observed in Study 1a). A new public health initiative is gaining support to provide recommendations to limit sedentary time as well as increasing physical activity for the promotion of physical health (Owen et al., 2010). The same recommendations to sit less and move more may also be warranted for optimal psychological health and well-being.

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Notes

1. Participants exhibiting varying levels of mental health, ranging from depression to flourishing mental health, were recontacted to complete a web-based version of the DRM as part of a larger study focused on how individuals with different levels of mental health (e.g. flourishers, non-flourishers and people with depression) respond emotionally to routine activities (Catalino & Fredrickson, 2011). Participants who completed Study 1a only, Study 1a and the first part of Study 1b only, and those who completed Study 1a and both parts of Study 1b did not differ in physical activity ($F(2548) = .70$, $p = .455$), sedentary behaviour ($F(2, 601) = .57$, $p = .566$), positive emotions ($F(2612) = .20$, $p = .822$) or psychosocial resources ($F(2, 620) = .11$, $p = .891$), age ($F(2602) = .77$, $p = .462$), gender (χ^2 (2) = 2.74, $p = .254$) or education (χ^2 (2) = 2.84, $p = .242$). A higher percentage of participants who completed Study 1a and both time points for Study 1b described their race as 'White' relative to participants who completed Study 1a only and Study 1a and the first part of Study 1b only (χ^2 (2) = 11.52, $p = .003$). Participants who completed Study 1a and both time points for Study 1b reported lower levels of negative emotions ($F(2612) = 3.36$, $p = .036$).
2. Statistical significance of all reported results for Study 1b was unchanged when mental health status (i.e. flourisher, non-flourisher or person with depression) was included as a covariate.

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