

Correlates of objectively measured physical activity in adults and older people: a cross-sectional study of population-based sample of adults and older people living in Norway

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Abstract

Objectives The aims of the study were to identify correlates of objectively measured physical activity and to determine whether the explanatory power of the correlates differed with sex, weight status or level of education.

Methods Physical activity was assessed objectively in 3,867 participants, aged 20–85 years, for a consecutive 7 days using the ActiGraph GT1M activity monitor. Demographic and biological variables and levels of psychological, social environmental and physical environmental correlates were self-reported.

Results The complete set of correlates explained 18.6 % ($p < 0.001$) of the variance in overall physical activity. Age and physical activity identity were the most important factors, explaining 4.8 and 3.2 % of the variance, respectively, whereas social environmental and physical environmental correlates did not significantly increase the amount of explained variance. Small interaction effects

between demographic and biological variables and the correlates were observed.

Conclusions Self-efficacy, perceived behavioural control and physical activity identity might be important targets for intervention. Intervention efforts aimed at influencing psychological correlates of physical activity may prove equally effective regardless of sex, weight status and level of education.

Keywords Actigraphy · Physical activity · Correlates of physical activity · Epidemiology · Public health

Introduction

Regular physical activity yields numerous health benefits (Haskell et al. 2007). However, the available data on population levels of physical activity indicate that this evidence has failed to stimulate a large proportion of adults and older people to become more physically active (Bouchard et al. 2012; Hagstromer et al. 2010). To counteract increases in sedentariness, effective interventions are required to increase physical activity at the population level. To develop such interventions, a comprehensive platform of knowledge on the factors that correlate with physical activity is needed (Bryan et al. 2007). Although the literature includes many findings of cross-sectional associations and longitudinal relationships between demographic, biological, psychological, social environmental, and physical environmental variables (commonly referred to as correlates) and physical activity (Trost et al. 2002; Bauman et al. 2002; Bauman et al. 2012), these are generally based on self-reported physical activity. The use of self-reports of physical activity has limitations, and may

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provide imprecise estimates of physical activity (Sallis and Saelens 2000). The complexity of measuring physical activity or even the failure to do so adequately is one of the problems that have impeded our understanding of what motivates individuals to adopt and maintain an active lifestyle (Seefeldt et al. 2002).

Objective assessment of physical activity using activity monitors such as accelerometers has the potential to overcome many of the challenges related to self-reported physical activity. There is a paucity of studies using objectively assessed physical activity to investigate the association between physical activity and a broad range of biological, psychosocial and social environmental variables in a large population of adults and older people living in Scandinavia.

Furthermore, given the broad range and complexity of the factors that influence physical activity, research aimed at identifying its correlates should be conceptualized within a socio-ecological framework, allowing the integration of multiple levels and contexts to provide us with the best possible understanding of physical activity behaviour.

Additionally, as gradients in physical activity behaviour have been observed across ages and sexes, weight groups, and socio-economic positions in adults (Trost et al. 2002), it is important to assess whether such gradients interact with the predictive power of the correlates. If so, the directions and strengths of such interactions will indicate whether certain strata of the population require tailored interventions to increase their physical activity.

Therefore, the aims of this study were (1) to ascertain the predictive power of a broad range of demographic, biological, psychological, social environmental, and physical environmental correlates of physical activity on objectively measured overall physical activity in a population of adults and older people; and (2) to identify and assess the potential moderating effects of demographic and biological variables on the relationship between the correlates and objectively measured physical activity.

Methods

Study design and sample

This was a nationally representative cross-sectional multi-centre study of objectively measured physical activity conducted in 2008–2009. In total, ten test-centres collected data from selected adjacent municipalities across Norway. Written informed consent was obtained from 3,867 individuals (34 % of the invited sample). Detailed information on the flow of invitees and the results of a drop-out analysis performed via registry linkage are presented elsewhere (Hansen et al. 2012). In brief, compared with the responders, the non-responders were somewhat less educated and had a

slightly lower income, and more likely to originate from countries other than Norway. The study was approved by the Regional Ethics Committee for Medical Research and the Norwegian Social Science Data Services AS.

Measures

Physical activity

Physical activity was measured using the ActiGraph GT1M activity monitor (ActiGraph, LLC, Pensacola, FL, USA), a valid (Plasqui and Westerterp 2007) and reliable (McClain et al. 2007) hip-worn electronic motion sensor. Vertical acceleration is converted into movement counts that increase linearly with the magnitude of the acceleration (i.e. intensity). A SAS-based macro was used to reduce the raw movement counts into an estimate of overall physical activity. The movement counts registered each user-defined time interval (epoch) were averaged over the total wearing time (counts per minute; CPM). Sequences of consecutive zero counts lasting ≥ 60 min were interpreted as representing non-wear time and excluded from each individual recording. A valid recording of a participant's activity level was defined as having at least 10 h of daily wear time for at least 4 days.

Demographic and biological variables

Age, sex, height, and weight were self-reported. As reported previously, overall physical activity remained steady with age, until 65 years, after which activity levels declined (Hansen et al. 2012). Age was therefore dichotomised into two age groups (20–64 and 65+ years) before entered into the regression analysis. Body mass index (BMI) was computed as weight (kg) divided by metres squared (m^2) and categorised according to WHO guidelines (World Health Organization 2000), with overweight and obesity defined as BMIs of 25–30 and >30 kg/m^2 , respectively. Because of the small sample size, underweight participants ($n = 35$) were included in the normal weight category; this did not cause any significant changes in physical activity for the normal weight participants. Participants were asked to rate their perceived health status as very poor, poor, fair, good, or very good. Because of the low prevalence of poor health ($n = 104$, 3.0 %) and very poor health ($n = 3$, 0.1 %), the answers were grouped into two categories for the analysis: very poor/poor/fair and good/very good (“not good” vs. “good”). Educational attainment was categorised into four groups: less than high school, high school, less than 4 years of university, and university for 4 years or more. Smoking habits, marital status and number of children were reported and dichotomised before the variables were entered into the analysis (smoking vs. not smoking, married vs. not married and children vs. no children, respectively).

Theoretical framework

The theoretical framework used to understand physical activity was the socio-ecological model (McLeroy et al. 1988; Stokols et al. 1996), which describes multiple levels of influence, from the intra-individual level to the community/environmental level. All psychological, social environmental and physical environment variables were derived from previously developed and validated scales.

Psychological variables

The psychological variables considered likely to be correlates of physical activity were self-efficacy for physical activity (Bandura 2004; Fuchs and Schwarzer 1994), perceived behavioural control over physical activity (Ajzen and Madden 1986; Norman and Smith 1995), and physical activity identity (Jackson et al. 2003; Lorentzen et al. 2007b). Self-efficacy for physical activity was assessed using a five-item measure, where the participants indicated on a seven-point Likert scale (with “not at all confident” and “very confident” at opposite ends of the continuum) the extent to which they were confident in their ability to perform planned physical activity in the face of potential barriers. A mean score for all the constituent items was computed, with higher scores indicating a greater amount of self-efficacy for physical activity. Only participants with a response rate of 75 % or greater for the respective item in each subscale were included when the mean scores were computed (allowance for two missing items). The self-efficacy measure displayed a high degree of internal consistency (Cronbach’s alpha [α] of 0.91). Perceived behavioural control was assessed with items assessing the individual’s perception of his/her personal control over being regularly physically active. The measure showed a relatively high degree of internal consistency ($\alpha = 0.67$). Physical activity identity was assessed with four items, which the participants rated on a five-point scale ranging from 1 (fits badly) to 5 (fits well) of the degree to which different statements described them with respect to physical activity. The measure showed good internal consistency ($\alpha = 0.91$).

Social environmental variables

The social environmental variables likely to correlate with physical activity were social support, from either family or friends. Social support was measured using an 11-item scale divided into two sections: one concerning support received from family, and the other concerning the support received from friends, acquaintances, and co-workers. Participants rated separately how often their family and friends/acquaintances/co-workers had been supportive of

their physical activity. The response to each item was based on a five-point scale, ranging from 1 (never) to 5 (very often). The participants could also answer “does not apply to me”, which was treated as missing data. A family support measure and a friend support measure comprising five of the 11 items used in the present friend support scale have previously shown acceptable reliability and criterion-related validity (Sallis et al. 1987; Lorentzen et al. 2007a). In the present study, Cronbach’s α was 0.86 for the family support subscale and 0.89 for the friend support subscale. For each scale/subscale, a mean score of all constituent items was computed, with higher scores indicating a greater amount of support for PA, and only participants with a response rate of 75 % or greater for the respective item in each subscale were included when the mean scores were computed (allowance for one missing item).

Physical environmental variables

The inclusion of the physical environmental variables was guided by the empirical literature on the environmental factors that have been associated with physical activity in various settings and population groups (Brownson et al. 2001; Saelens and Handy 2008; Van Holle et al. 2012). Hence, perceived community attributes were measured with a seven-item measure, in which the participants indicated on a four-point Likert scale the extent to which they agreed or disagreed with statements describing their community (regarding pedestrian street safety, safety of recreation areas/parks, walking/cycling facilities, access to shops, access to physical activity facilities/places and organised offers for physical activity) on a scale ranging from 1 (don’t agree) to 4 (agree) (Saelens et al. 2003; Booth et al. 2000). The measure showed good internal consistency ($\alpha = 0.79$).

Statistical methods

All statistical analyses were performed with PASW Statistics 18 for Windows (IBM Corporation, Somers, NY, USA). Descriptive data are presented as proportions, means and standard deviations (SD) or standard errors of the mean (SE), and 95 % confidence intervals (CI) where appropriate. Differences in objectively assessed physical activity and anthropometric data were assessed with analyses of variance with the Bonferroni post hoc test for multiple comparisons.

To analyse the relationships between the outcome variables, CPM and the sets of potential correlates for physical activity, hierarchical regression was applied with the principle of hierarchical ordering of proximal versus distal variables based on a socio-ecological framework (Stokols et al. 1996). Preliminary analyses were conducted

to ensure that there was no violation of the assumptions of linear regression. The analysis was built up from consecutive blocks containing categories of variables, in which the order of the blocks was based on their relative proximity to the individual. This approach ensures that increases in the explained variance in overall physical activity between individuals (multiple correlations squared, R^2) added by adding a new block can be attributed solely to the variables in the added block. Demographic and biological variables were entered as block 1. The inclusion of demographic and biological variables in block 1 was based on their association with physical activity shown in epidemiological studies (Trost et al. 2002) and ensured that the amount of variance explained in the following blocks was independent of these variables. Block 2 contained the psychological variables (self-efficacy, perceived behavioural control, and physical activity identity), reflecting greater proximity to the individual than the more distal social environmental variables (social support from family and friends), which were included in block 3. The physical environmental variables (perceived community attributes) were entered in block 4. Unstandardized coefficients (b) and the individual contribution of each predictor variable to the explained variance (semi-partial correlation squared) are reported.

To investigate the potential moderating effects of the demographic and biological variables on the relationships between the psychological, social environmental and physical environmental variables and physical activity, the interaction terms for the demographic and biological variables and the potential correlates were computed (e.g. sex multiplied by self-efficacy). The potential correlates

were mean centred before the interaction terms were computed to avoid the potential bias of multicollinearity. The initial regression analyses were re-run, with block 1 consisting of the demographic and biological variables, excluding the potential moderator being investigated, block 2 containing the potential moderator and the potential correlate being investigated, while the corresponding interaction term was added in block 3. This procedure was repeated for each potential correlate, resulting in six separate regressions for each potential moderator variable. To graphically display and explore the directions and strengths of the significant interactions, the potential correlates were ordered in moderator-split tertiles (tertile 1: low score; tertile 2: moderate score; and tertile 3: high score), and analysis of covariance was then applied to explore the overall physical activity for each tertile, adjusted for the demographic and biological variables.

Results

Descriptive data are provided in Table 1. The mean age (SD) of the sample was 49.1 years (14.9) and the average BMI was 25.5 kg/m² (4.0), with 47 % of the study population being either overweight or obese. Women and men did not differ in their overall physical activity levels and activity remained constant with increasing age until 65 years, after which activity levels declined (data not shown).

The mean scores for the psychological and social environmental variables were moderate and relatively high, respectively, while the mean scores for the physical

Table 1 Physical activity and anthropometric data for all participants and by sex, Norway (2008–2009)

	Mean	(SD)	Mean	(SD)	Mean	(SD)	
Physical activity ^a	All	(<i>n</i> = 3,267)	Women	(<i>n</i> = 1,747)	Men	(<i>n</i> = 1,520)	
Overall PA (counts/min)	338	(2.4)	335	(3.3)	342	(3.6)	ns
Anthropometric data							
Age (years)	49.1	(14.9)	48.3	(15.0)	50.0	(15.0)	**
Height (cm)	173.0	(9.1)	166.9	(6.1)	180.1	(6.5)	**
Weight (kg)	76.6	(14.8)	69.3	(12.3)	85.0	(12.8)	**
BMI (kg/m ²)	25.5	(4.0)	24.9	(4.3)	26.2	(3.5)	**
Overweight (%) ^b	35.3		29.7		45.6		**
Obese (%) ^d	11.4		10.9		13.3		**

Values are means (SD), except for overall PA where standard error of the mean (SE) is reported

NS non-significant, SD standard deviation

^a Activity variables are adjusted for age and test centre

^b Values are presented as proportions (%)

Significant test for women compared with men

* $p < 0.05$

** $p \leq 0.001$

Table 2 Psychosocial and socio-environmental variables with Cronbach's α , and examples of scale items, Norway (2008–2009)

	Scale range	Mean (SD)	α
Biological variable			
Weight category: overweight/obese (%)	NA	46.7 (NA)	NA
Psychological variables			
Self-efficacy	1–7	5.2 (1.4)	0.91
“I am sure that I can perform the planned physical activity even though I am tired”			
Perceived behavioural control	1–7	5.0 (1.3)	0.67
“I control whether I perform regular physical activity or not”			
Physical activity identity	1–5	3.5 (1.0)	0.91
“Being physically active is a part of being the person I am”			
Social environmental variables			
Social support from family	1–5	2.9 (0.9)	0.86
“How often do members of your family change their plans so that they can be physically active with you”			
Social support from friends	1–5	2.6 (0.9)	0.89
“How often do your friends change their plans so that they can be physically active with you?”			
Physical environmental variables			
Perceived community attributes	1–4	3.3 (0.7)	0.79
“To what extent does your community have: safe places where you can walk?”			

NA; not applicable

environment variables were high (a mean score of 3.3 of 4.0) (Table 2). Compared with women, men reported lower levels of social support from friends (2.5 vs. 2.7, respectively, $p \leq 0.001$), and higher levels of perceived behavioural control (5.1 vs. 4.9, $p \leq 0.001$). No other sex-based differences were observed.

The demographic and biological factors included in the model (block 1) accounted for 11.9 % of the variance in overall physical activity ($R^2 = 0.119$, $p \leq 0.001$) (Table 3). Age group, health status, and weight status displayed the largest amount of explanatory power, explaining 4.1, 4.4 and 2.3 % of the variance, respectively ($p \leq 0.001$). The psychological variables of self-efficacy, perceived behavioural control and physical activity identity (block 3) increased the total explained variance to 18.6 % ($p \leq 0.001$). Although age group, health status, and weight status remained significant throughout the addition of the blocks of variables, their predictive power changed somewhat. In the fully adjusted model, age group accounted for 4.8 % of the explained variance ($p \leq 0.001$), whereas the predictive power of health status and weight status decreased to 1.5 and 1.2 %, respectively ($p \leq 0.001$). Each of the psychological correlates individually contributed to increasing the explanatory power of the model, with physical activity identity being the most important factor, individually explaining 3.4 % of the variance ($p \leq 0.001$). The social environmental variables (block 3) (perceived social support from family and friends) and the physical environmental variable (block 4) yielded no further

significant increases in amount of variance explained by the total set of variables.

Altogether, seven of the 22 interaction terms contributed significantly to increasing the explanatory power of the predictor variables, indicating that these moderated the relationships between the sets of variables, now established as correlates, and physical activity. However, the effect sizes were small (Table 4), and visual inspection of the relationships between the correlates and physical activity, split by the potential moderator, indicated that none of the interaction terms altered the relationships sufficiently to have any significant relevance to the predictive power of the correlates in any of the specified subgroups (Figs. 1, 2, 3).

Discussion

Using a social ecological framework, this study examined correlates of accelerometer-determined overall physical activity in a large population-based sample of Norwegian adults and older people.

The total independent variable set accounted for 18.6 % of the explained variance in overall physical activity. Age group (below or above 65 years) was the most important predictor of overall activity level, uniquely explaining 4.8 % of the variance in the dependent variable, a finding that is consistent with findings from studies using self-reported measures of physical activity (Troost et al. 2002).

Table 3 Hierarchical regression analysis of variables of overall physical activity (mean counts per minute), Norway (2008–2009)

Fixed effects	Block 1		Block 2		Block 3		Block 4		Partial R^2
	<i>b</i>	(SE)	<i>b</i>	(SE)	<i>b</i>	(SE)	<i>b</i>	(SE)	
Intercept	300.2	(20.8) ^{***}	212.9	(23.8) ^{***}	214.7	(24.8) ^{***}	210.1	(26.3) ^{***}	
Demographic variables									
Age group (20–64 vs. 65–85 years)	–73.3	(6.7) ^{***}	–78.1	(6.5) ^{***}	–78.2	(6.5) ^{***}	–78.1	(6.5) ^{***}	0.048
Sex (female vs. male)	13.4	(5.0) ^{***}	9.8	(4.8) [*]	9.8	(4.9) [*]	9.7	(4.9) [*]	0.001
Have children (yes vs. no)	3.5	(7.0)	2.6	(6.7)	2.6	(6.7)	2.6	(6.7)	0.000
Smoking habits (smoker vs. non-smoker)	36.8	(6.7) ^{***}	20.9	(6.6) ^{**}	21.0	(6.6) ^{**}	21.1	(6.6) ^{**}	0.004
Health status (not good vs. good)	68.0	(5.9) ^{***}	39.8	(6.0) ^{***}	39.8	(6.0) ^{***}	39.6	(6.0) ^{***}	0.015
Level of education (low vs. high)	–14.1	(5.1) [*]	–20.2	(5.0) ^{***}	–20.1	(5.0) ^{***}	–20.3	(2.5) ^{**}	0.006
Marital status (married vs. unmarried)	–2.7	(5.4)	–4.6	(5.2)	–4.3	(5.2)	–5.0	(5.3)	0.000
Biological variables									
Weight category ^a	–41.6	(5.1) ^{***}	–29.7	(5.0) ^{***}	–29.7	(5.0) ^{***}	–29.6	(5.0) ^{***}	0.012
Psychological variables									
Self-efficacy			4.6	(1.9) [*]	4.6	(1.9) [*]	4.6	(1.9) [*]	0.002
Perceived behavioural control			10.2	(2.1) ^{***}	10.2	(2.1) ^{***}	10.2	(2.1) ^{***}	0.008
Physical activity identity			27.7	(2.8) ^{***}	27.9	(2.9) ^{***}	27.9	(2.9) ^{***}	0.032
Social environmental variables									
Social support from family					–1.5	(3.2)	–1.3	(3.2)	0.000
Social support from friends					0.4	(3.3)	0.3	(3.3)	0.000
Physical environmental variables									
Perceived community attributes									
Explained variance (R^2)	0.119 ^{***}		0.186 ^{***}		0.186		1.9	(3.7)	0.000

b Unstandardized beta coefficient, *SE* standard error of the mean

^a Weight category code: 1 = normal weight, 2 = overweight/obese

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

Table 4 Interaction effects of potential moderators of the relationship between correlates and moderate-to-vigorous physical activity, Norway (2008–2009)

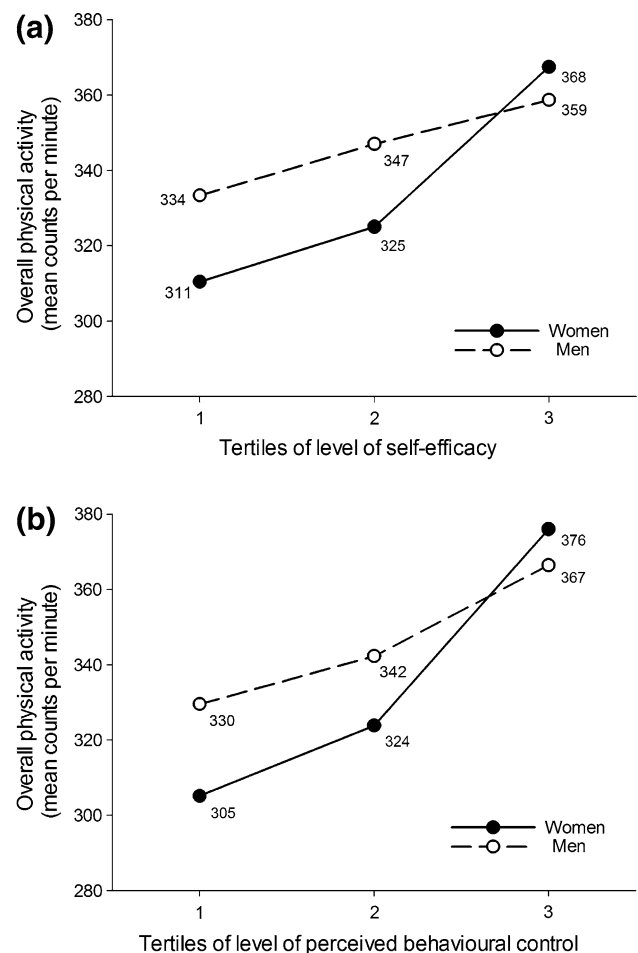
Variables included in block	R^2*100	p value
Sex and self-efficacy	13.9	
Interaction term: sex \times self-efficacy	14.2	0.001
Sex and perceived behavioural control	14.9	
Interaction term: sex \times perceived behavioural control	15.0	0.014
Sex and perceived community attributes*	12.1	
Interaction term: sex \times perception of community attributes	12.3	0.003
Weight status and self-efficacy	13.9	
Interaction term: weight status \times self-efficacy	14.2	0.001
Weight status and perceived behavioural control	14.9	
Interaction term: weight status \times perceived behavioural control	15.0	0.016
Level of education and self-efficacy	13.9	
Interaction term: level of education \times self-efficacy	14.1	0.004

R^2*100 percentage explained variance in overall physical activity (mean counts per minute)

Further, in contrast to much of the published literature on levels of physical activity, no sex gradient in overall physical activity was observed (Trost et al. 2002). This is, however, consistent with more recent studies of population levels of objectively measured physical activity (Hagstromer et al. 2010), and might reflect the activity monitors increased ability to capture a broader spectrum of physical activity compared to self-reported measures (Hansen et al. 2012).

Concerning the remaining demographic and biological variables, the results of the current study are in conjunction with other studies. As reported by others, civil status was not associated with physical activity (Brownson et al. 2000; King et al. 2000) and smoking status was inversely related to physical activity (Johnson et al. 1998; Brownson et al. 2000). Overweight and obesity was associated with lower levels of physical activity after controlling for potential demographic confounders, as consistently reported in the literature (Martinez-Gonzalez et al. 1999).

Self-efficacy was a significant independent contributor to overall physical activity in the present study. This finding confirms earlier findings of self-efficacy as a correlate that is positively associated with adoption and maintenance of physical activity (Bandura 1997; Bauman et al. 2012; Sallis et al. 1986). Perceived behavioural control is an individual's perception of the extent to which regularly maintaining the behaviour is easy or difficult and may influence behaviour directly and through the intentions to act (Ajzen and Madden 1986). A number of studies have found that perceived behavioural control predicts

**Fig. 1** Relationship between overall physical activity and self-efficacy (a) or perceived behavioural control (b) by sex, Norway (2008–2009)

physical activity behaviour (Hagger et al. 2002; Jackson et al. 2003), which was also observed in the present study. Physical activity identity was the strongest predictor of all the correlates and yielded a significant independent addition of variance accounted for in physical activity, equal to age group in size. The explanatory power of physical activity identity is supported by others. In a community-based study of 2,336 adults living in Norway, physical activity identity was found to be the strongest predictor of forward transition in the stages of change in physical activity (Lorentzen et al. 2007b). The relevance of activity identity as a correlate of physical activity was also confirmed in earlier studies of self-reported physical activity (Anderson and Cychosz 1995), and these earlier findings combined with the results of the current study provide strong evidence for the inclusion of attempts to foster the development of individual's physical activity identity in interventions aimed at enhancing physical activity behaviour. However, past interventions to increase physical activity aimed solely at cognitive and psychosocial

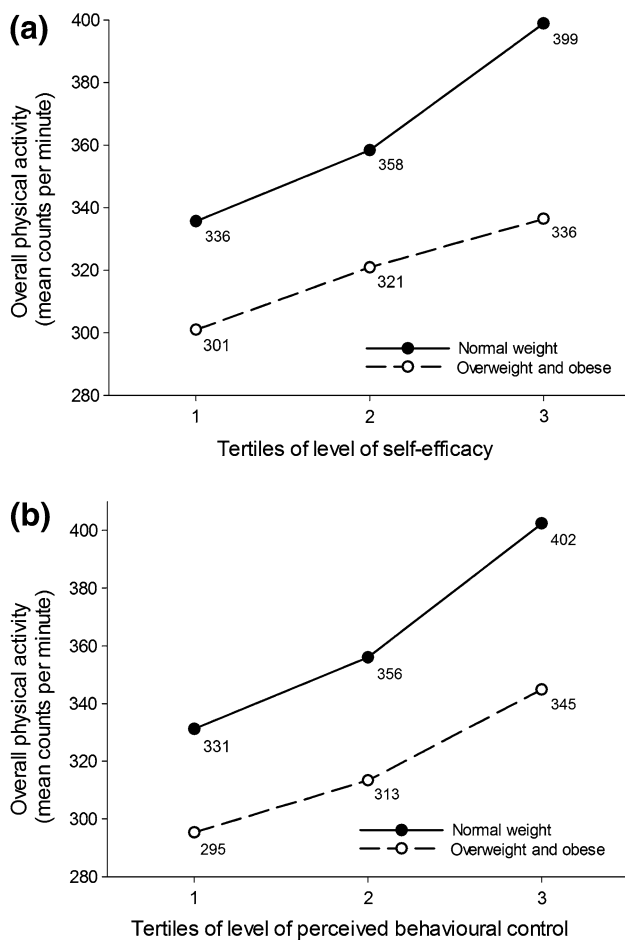


Fig. 2 Relationship between overall physical activity and self-efficacy (a) or perceived behavioural control (b) by weight status, Norway (2008–2009)

variables have generally produced small effect sizes and usually the behaviour changes were not sustainable, proliferating ecological models of health behaviour that posit the need for multi-level interventions (Sallis et al. 2008; Stokols et al. 1996).

According to the literature, social support is a consistent correlate of physical activity (Bauman et al. 2012; Trost et al. 2002). In our model, however, social support neither from friends nor family emerged as a significant contributor to the explanatory power of the model after controlling for demographic and biological variables and psychological correlates. This has also been observed by others (Hall and McAuley 2010). Further, perceived community attributes did not relate significantly to overall physical activity. A similar finding was reported in a review by Wendel-Vos et al. (2007), reporting that availability, accessibility and convenience of recreational facilities were less consistent correlates of physical activity, possibly due to the use of non-validated measures of environments and/or behaviour. The item measuring perceived community

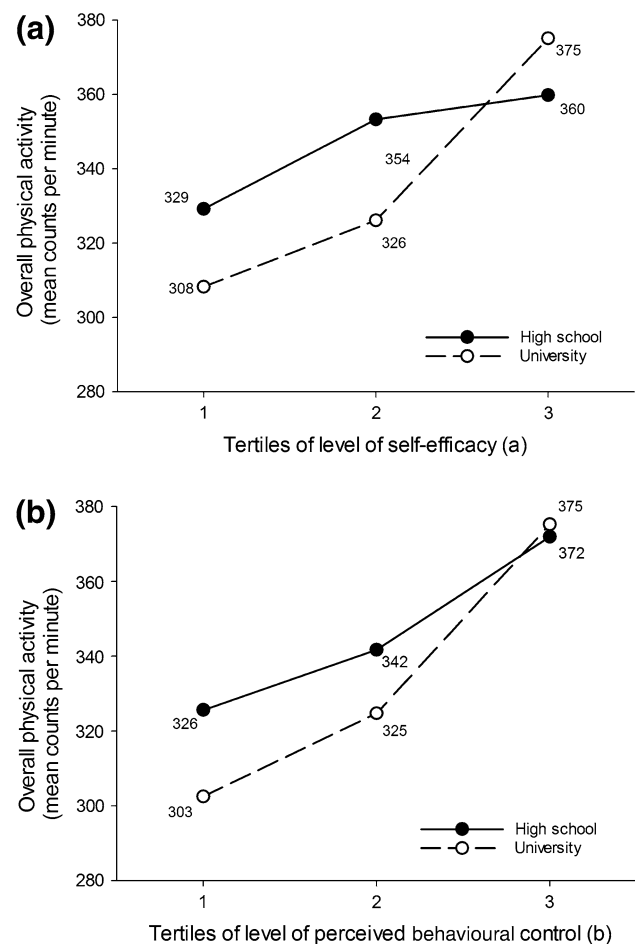


Fig. 3 Relationship between overall physical activity and self-efficacy (a) or perceived behavioural control (b) by level of education, Norway (2008–2009)

attributes in the present study displayed reasonable internal consistency, but the mean score was relatively high with little variance and might, therefore, not be able to discriminate sufficiently between high and low levels of community attributes. Furthermore, the addition of perceived environment measures that assessed multiple features of physical environment would have strengthened the study. Ideally, objective measurement of neighbourhood walkability, street connectivity, population density and sidewalk conditions would be ideal for this purpose, and might yield different results (Wendel-Vos et al. 2007).

There were significant interaction effects of the demographic and biological variables in the relationship between the different correlates and physical activity. However, the size of the interaction effects (as displayed in Table 4 and Figs. 1, 2, 3) should be considered as relatively modest. Hence, the interaction findings would seem encouraging by indicating that tailoring strategies to increase overall physical activity in the population according to sex, weight or level of education do not seem necessary.

The study is not without limitations. The cross-sectional design of the study prohibits the establishment of causality. Furthermore, the response rate might be considered low, which increases the risk for selection bias (Sogaard et al. 2004; Van Loon et al. 2003). Analyses of the non-responders in our study revealed that non-responders were more likely to be either at the younger or older end of the age spectrum, unmarried and with lower educational and income levels, compared to the responders (Hansen et al. 2012), as observed in most population-based surveys (Sogaard et al. 2004; Strandhagen et al. 2010). In addition, the prevalence of overweight or obesity and other non-communicable diseases, such as type 2 diabetes, was similar to other national estimates. Therefore, we believe that the results of the current study have a general validity corresponding to similar studies.

We also acknowledge that the choice of CPM as the main outcome variable might be debatable as it provides some challenges related to the interpretation of the public health significance of the study. This might have been avoided using an indicator of intensity-specific physical activity, such as number of minutes above a certain count threshold (e.g. moderate-to-vigorous physical activity; MVPA). However, the appliance of cut-points for intensity-specific physical activity is associated with challenges, especially in a sample that is heterogeneous with respect to age and weight status. The CPM variable is not affected by any external manipulation and we believe that this variable is the best indicator of the participants' level of overall physical activity. However, additional analysis with MVPA as the dependent variable yielded very similar results (data not shown). The overall explained variance with MVPA as the dependent variable was 17.7 %, compared to 18.6 % when CPM was used, and the same variables were significant correlates of activity.

Lastly, there is emerging evidence on other possible correlates of physical activity, such as genetic and policy related determinants. The inclusion of such factors has the potential to increase our understanding of the correlates of physical activity, but this is beyond the scope of this article.

In spite of these limitations, the present study contributes to the understanding of physical activity and its correlates. The results of the study can serve as an empirical evaluation of a social ecological model of physical activity and the order of entry of blocks of variables into the hierarchical regression model is of relevance to intervention design. Demographic and biological variables that are not modifiable were entered first, allowing the explained variance (R^2) for the following blocks to serve as a theoretical estimate of change that could be expected by changing variables in the blocks. Although the independent explanatory power of each correlates was relatively modest, they yield important information as there

is consistent evidence showing that small increases in physical activity can benefit people's health significantly (Hill 2009; Levine et al. 2000).

Conclusion

Several correlates that might be important targets for intervention were identified. These variables include self-efficacy, perceived behavioural control and physical activity identity.

The observed interaction effects of the demographic and biological variables on the relationships between the correlates and physical activity did not seem to have a sufficient impact to justify interventions that are specific for sex, weight status, or level of education.

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Conflict of interest The authors declare that they have no competing interests.

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