



UNIVERSITY OF
GLOUCESTERSHIRE

This is a peer-reviewed, post-print (final draft post-refereeing) version of the following published document and is licensed under All Rights Reserved license:

Owens, C, Crone, Diane, De Ste Croix, Mark B ORCID: 0000-0001-9911-4355, Gidlow, Christopher J and James, David V ORCID: 0000-0002-0805-7453 (2014) Physical activity and screen time in adolescents transitioning out of compulsory education: a prospective longitudinal study. Journal of Public Health, 36 (4). pp. 599-607. ISSN 1741-3842

Official URL: <http://jpubhealth.oxfordjournals.org/cgi/content/abstract/fdt123?>

DOI: <http://dx.doi.org/10.1093/pubmed/fdt123>

EPrint URI: <http://eprints.glos.ac.uk/id/eprint/415>

Disclaimer

The University of Gloucestershire has obtained warranties from all depositors as to their title in the material deposited and as to their right to deposit such material.

The University of Gloucestershire makes no representation or warranties of commercial utility, title, or fitness for a particular purpose or any other warranty, express or implied in respect of any material deposited.

The University of Gloucestershire makes no representation that the use of the materials will not infringe any patent, copyright, trademark or other property or proprietary rights.

The University of Gloucestershire accepts no liability for any infringement of intellectual property rights in any material deposited but will remove such material from public view pending investigation in the event of an allegation of any such infringement.

PLEASE SCROLL DOWN FOR TEXT.

This is a peer-reviewed, post-print (final draft post-refereeing) version of the following published document and is licensed under All Rights Reserved license:

Owens, C and Crone, Diane and De Ste Croix, Mark B and Gidlow, Christopher J and James, David V (2014) Physical activity and screen time in adolescents transitioning out of compulsory education: a prospective longitudinal study. Journal of Public Health, 36 (4). pp. 599-607. ISSN 1741-3842

Official URL: <http://jpubhealth.oxfordjournals.org/cgi/content/abstract/fdt123?>

DOI: <http://dx.doi.org/10.1093/pubmed/fdt123>

EPrint URI: <http://eprints.glos.ac.uk/id/eprint/415>

Disclaimer

The University of Gloucestershire has obtained warranties from all depositors as to their title in the material deposited and as to their right to deposit such material.

The University of Gloucestershire makes no representation or warranties of commercial utility, title, or fitness for a particular purpose or any other warranty, express or implied in respect of any material deposited.

The University of Gloucestershire makes no representation that the use of the materials will not infringe any patent, copyright, trademark or other property or proprietary rights.

The University of Gloucestershire accepts no liability for any infringement of intellectual property rights in any material deposited but will remove such material from public view pending investigation in the event of an allegation of any such infringement.

PLEASE SCROLL DOWN FOR TEXT.

Title

Physical activity and screen time in adolescents transitioning out of compulsory education: A prospective longitudinal study

Authors

Owens, C.S.¹

Crone, D.²

De Ste Croix, M.B.A.²

Gidlow, C.J.³

James, D.V.B.²

¹Faculty of Medicine and Health Sciences, Division of Epidemiology and Public Health, School of Medicine, University of Nottingham, Nottingham, NG5 1PB, UK

²Faculty of Applied Sciences, School of Sport and Exercise, University of Gloucestershire, Gloucester, GL2 9HW, UK

³Centre for Sport, Health and Exercise Research, Staffordshire University, Stoke-on-Trent, ST4 2DF, UK

Corresponding author

¹Owens, C.S.

Email address of corresponding author - Christopher.Owens@nottingham.ac.uk

Abstract

Background

Within the UK context, it is unclear whether physical activity and screen time changes between completing compulsory education and the period afterwards, and the factors associated with any change.

Methods

A prospective population-based longitudinal design among adolescents (n = 2204 at baseline) was adopted. A self-report questionnaire was administered at baseline (final year of compulsory education) and follow-up (i.e., post compulsory education) to measure physical activity over the previous 7 days and screen time (weekday and weekend) in relation to recommended guidelines. Magnitude of change in physical activity and screen time and key influencing variables associated with changes were analysed.

Results

For physical activity, there was a significant change in participants meeting guidelines at baseline but not meeting guidelines at follow-up with 81.0% not meeting guidelines at baseline and follow-up. For screen time, there was no significant change between baseline and follow-up, with 70.6% not meeting guidelines at baseline and follow-up. Gender was associated with the change in physical activity with a decline less likely in females.

Conclusions

Findings reinforce the importance of reducing physical inactivity and sedentary behaviour during this transition. Factors associated with changes in physical inactivity and sedentary behaviour need further investigation.

Keywords

Inactivity, sedentary behaviour, observational, correlates, youth, school, self-report

Introduction

Many adolescents in the United Kingdom (UK) are insufficiently physically active and spend too much time engaged in sedentary behaviour.¹ In line with many other countries, UK guidelines for physical activity recommend that children and young people accumulate at least 60 minutes (and up to several hours) per day of moderate to vigorous intensity physical activity.² Moderate to vigorous intensity physical activity includes physical activities that range between breathing faster and an increase in heart rate (moderate) to breathing very hard and having a rapid heartbeat (vigorous).² The UK does not have a specific recommendation for sedentary behaviour although it is generally suggested that children and young people limit sedentary 'sitting' time for extended periods.² Studies investigating adolescents' compliance with sedentary behaviour guidelines commonly use screen time (time spent watching television and using a computer) as the measured 'proxy' variable, since total time in sedentary behaviour is difficult to measure, and it has been shown that screen time constitutes a large proportion of total sedentary behaviour.³ Some guidelines (e.g., American Academy of Pediatrics) recommend that children and young people should not spend more than 2 hours a day engaged in screen based activities.⁴⁻⁶ In some studies, sedentary behaviour has been misunderstood to be solely a lack of physical activity (i.e., physical inactivity).^{7,8} It has been suggested that sedentary behaviour is both a subset of physical inactivity⁹ and also an independent behaviour that may or may not be associated with overall inactivity.^{10,11} Sedentary behaviours, such as television viewing, are characterised by a postural position of 'sitting' or 'lying' and very low energy expenditure.^{2,12}

Studies have shown a decline in physical activity throughout adolescence, however many of these studies are cross-sectional in nature.¹³ Investigations of sedentary behaviour are less conclusive, and this may be a result of both the limited number of studies and the use of varied proxy measures. Very few studies have simultaneously investigated physical activity and sedentary behaviour, especially beyond cross-sectional research. A key transition phase during adolescence in the UK is the period between completing compulsory education at age 16 years and then beginning further education (e.g., sixth form) or training/employment.¹⁴ More specifically, school leavers have a number of options when they complete compulsory education including sixth form at school/sixth form at a further education college, more

generally going to a further education college with no sixth form, starting an apprenticeship/training programme, general employment or unemployment. The common perception is that physical activity declines and sedentary behaviour increases during this period, but no studies in the UK provide clear evidence for this assertion based on a longitudinal design. The development of chronic diseases may be influenced by such behaviours during adolescence, and this transition phase is also important in determining on-going patterns of behaviour into adulthood.¹⁵

The study of factors associated with adolescents' physical activity is developing demonstrated by systematic reviews of correlates¹⁶⁻¹⁹, determinants^{20,21} and reviews of systematic reviews.²²⁻²⁴ In comparison, research into the factors associated with adolescents' sedentary behaviour (typically 'screen viewing') is less developed but gaining momentum as evidenced in systematic reviews of correlates^{18,25,26} and determinants.²¹ These reviews indicate that cross-sectional studies dominate the evidence base. Prospective longitudinal studies investigating factors associated with a 'change' in adolescents' physical activity and/or sedentary behaviour are rare, and none focus on the important transition out of compulsory education in the UK. Factors associated with adolescents' physical activity and sedentary behaviour may be identified through an ecological model which is centred on an inter-relationship between intrapersonal, interpersonal and environmental factors, which influence health behaviours such as physical activity and sedentary behaviour.²⁷ The present study aimed to investigate a possible change in physical activity and screen time (as the proxy measure for sedentary behaviour), and associated factors, longitudinally during the transition out of compulsory education.

Methods

Study design and recruitment

This study was granted ethical approval by the Institutional Ethics Committee in February 2008. A prospective population-based longitudinal design was used. Data were collected via self-report questionnaire at two time points: at baseline, participants were still in compulsory education (Year 11); and at follow-up (post-compulsory education), participants had just completed the transition into further education (sixth form (e.g. at school) or further education college), employment/training or unemployment. At baseline, 24 out of 53 schools, in one

county in the UK, consented for the questionnaire to be administered to pupils. The baseline sample consisted of 2204 participants (male, n = 1191; female, n = 1009; unknown, n = 4) aged between 14 and 17 years (some 14 year or 17 year olds (n = 13) were placed in this particular year group for academic reasons). At follow-up, questionnaires were administered via school sixth form (Year 12) visits at 13 of the original 24 schools by these schools agreeing for the researcher to go back into the schools and administer the questionnaire with questionnaires being completed by 544 participants from the baseline cohort. The remainder of the baseline cohort were no longer in a School, and were therefore contacted via mail where contact details were available (n = 1255) and 342 completed questionnaires were received (27.3% response). At follow-up, in total, 886 (40.2%) participants of the original 2204 participants completed a questionnaire. For analyses, it was decided that two separate data sets would be considered: analysis one (A1) (n = 663) contained participants with complete data, including both postcode and associated output area (OA) code (male, n = 362; female, n = 301); analysis two (A2) (n = 834) contained participants with complete data, but missing postcode and/or associated OA code (male, n = 447; female, n = 387). The reason for having two separate data sets was due to both postcode and the associated OA code being required to determine the predictor variables of socioeconomic status and area of residence thus A1 included these predictor variables but A2 did not. Figure 1 summarises the cohort progress from baseline to follow-up.

Procedures

Data at baseline and follow-up were collected using a pre-piloted questionnaire, which was based on the physical activity and screen time questions used in a validated questionnaire; the Modifiable Activity Questionnaire for Adolescents.²⁸ The validity and reliability of the questionnaire has been reported in studies with adolescent populations.^{29,30} The physical activity and screen time questions were amended to align to the most recent UK recommended guidelines for physical activity³¹ and general screen time guidelines^{4,5} at the time of collecting data.

The outcome variable in this study was whether participants did or did not meet guidelines for physical activity³¹ (dichotomised as 7 days x 60 minutes vs. <7 days x 60 minutes) and screen time^{4,5} (dichotomised as ≤14 hours a week vs. >14 hours a

week). Physical activity was determined by asking participants the number of days in the previous 7 days they had undertaken a total of at least 60 minutes of at least moderate intensity sport or physical activity. The outcome variable for screen time was determined by asking participants the number of hours a day (on a weekday and on a weekend) they were engaged in a number of screen-based activities (e.g., television viewing, computer use). Total hours per week of screen time were calculated by multiplying the mid value of the option response range (e.g. '2 to 3 hours' (mid value of 2.5)) by 5 (for the weekday response) or 2 (for the weekend response). These two values were then added together to give the total weekly screen time.

Within the framework provided by an ecological model, and taking account of variables included in previous studies, the selected predictor variables consisted of intrapersonal factors (gender, ethnicity, educational attainment, socioeconomic status) and environmental factors (school type, area of residence). The number of predictor variables included for A1 and A2 was determined by a sample size assumption checking test being performed as advised by Peduzzi *et al.*³² The Townsend Index of Deprivation Score³³ was used as the indicator of socioeconomic status and calculated based on 2001 census data (using OA codes corresponding to participants' postcodes). Area of residence was determined using the Rural and Urban Area Classification³⁴ using a four-level (urban (population density >10,000); small town and fringe; village; and hamlet and isolated dwellings) and dichotomous categorisation as urban (population ≥10,000) or rural (population <10,000) based on OA code.

Statistical analyses

Following data cleaning, statistical analyses were undertaken using the Statistical Package for the Social Sciences version 16.0 (SPSS Inc., Chicago, IL, USA). Change over time from baseline to follow-up with regard to the outcome variables of meeting guidelines for physical activity and screen time (coded 0 for 'not meeting guidelines' and 1 for 'meeting guidelines') was investigated using the McNemar test for significance of changes. Factors associated with any significant 'change' were investigated using binary logistic regression through simultaneous entry of predictor variables. The outcome variable was coded 0 for the absence of the relevant change

in physical activity/screen time and 1 for the presence of the relevant change in physical activity/screen time. All predictor variables were treated as categorical variables.

Results

Change in physical activity and screen time

The descriptive statistics for all analyses (outcome variables and predictor variables) are presented in Table 1. As the findings are the same for A1 and A2, only A1 is referred to in the following results. At baseline, only a minority of participants were meeting guidelines for physical activity (14%) with 9.7% being male and 4.4% female (Table 1). For screen time, only 19.3% of participants were meeting guidelines with 10.4% being male and 8.9% female (Table 1). Similarly, at follow-up, only 8.9% were meeting guidelines for physical activity (6.2% male and 2.7% female) and 18.4% were meeting guidelines for screen time (10.1% male and 8.3% female) (Table 1). At baseline and follow-up, most of the sample remained in the same category of meeting or not meeting guidelines for physical activity (84.9%) and screen time (78.9%) (Table 2). Overall, at baseline and follow-up, the majority of participants were not meeting guidelines for physical activity (81%) and screen time (70.6%) with only a small minority meeting guidelines for physical activity (3.9%) and screen time (8.3%) (Table 2). However, there was a significant overall shift (i.e., a change) of participants from meeting physical activity guidelines at baseline to not meeting them at follow-up (Table 2). There was no significant change in compliance with screen time guidelines between baseline and follow-up (Table 2).

Investigation of factors associated with the 'change' in physical activity

As there was no significant change found for screen time (Table 2), only factors associated with the change (i.e., the decline) in physical activity were examined which encompassed a binary outcome: i. did not change from meeting guidelines at baseline to not meeting guidelines at follow-up (included participants 'not meeting guidelines at baseline to not meeting guidelines at follow-up', 'meeting guidelines at baseline to meeting guidelines at follow-up' or 'not meeting guidelines at baseline to meeting guidelines at follow-up') or ii. did change from meeting guidelines at baseline to not meeting guidelines at follow-up (included participants 'meeting guidelines at baseline to not meeting guidelines at follow-up'). Only gender was

associated with the change in physical activity. In comparison to males, females were 42.4% less likely to change from meeting guidelines at baseline to not meeting guidelines at follow-up (Table 3). No significant associations were found for the other predictor variables.

Discussion

Main findings of this study

The first finding to highlight is that the majority of participants were not meeting guidelines for physical activity (81.0%) or screen time (70.6%) at either baseline or follow-up with only a very small proportion of participants meeting guidelines for physical activity (3.9%) or screen time (8.3%) at either baseline or follow-up. These findings confirm the physical inactivity and high screen time levels of adolescents during this transitional period. There was no significant change in screen time between baseline and follow-up. Conversely, there was a decline in physical activity through the transition as demonstrated by the significant movement of participants from meeting guidelines at baseline (still in education), to not meeting guidelines at follow-up (post-compulsory education). The only factor associated with the change in physical activity through the transition was gender. More specifically, compared with males, being female was associated with a lower likelihood of a decline in physical activity during the transition from compulsory education.

What is already known on this topic

Self-report studies have shown that physical activity declines during adolescence in both cross-sectional^{35,36} and longitudinal³⁷⁻⁴¹ studies. In relation to adolescents' compliance with the general recommendation of 60 minutes moderate to vigorous physical activity per day, self-report studies have mainly been cross-sectional and have demonstrated varied compliance rates.⁴²⁻⁴⁴ Most self-report studies investigating sedentary behaviour among adolescents have been cross-sectional and indicate that screen time prevalence is high⁴⁵ and that specifically television viewing occupies the largest amount of total sedentary time.⁴⁶⁻⁴⁹ However, there are few longitudinal self-report studies examining changes in adolescents' screen time.^{41,50} The majority of adolescents' sedentary behaviour self-report compliance studies have also been cross-sectional and investigated screen time (or television viewing only) having adopted the recommended guideline of 2 hours a day for

screen time and identified that screen time compliance rates are low.^{44,51} No UK self-report studies have studied adolescents' compliance with recommended guidelines for physical activity or screen time over a longitudinal period during the transition out of compulsory education.

Systematic reviews on correlates of adolescents' physical activity¹⁶⁻¹⁹ and sedentary behaviour^{18,25,26} have mainly included cross-sectional studies with limited inclusion of longitudinal studies thus have not specifically focused on factors associated with changes in either behaviour. Across these reviews, there is limited consensus on the consistency for the factors of interest in the present study and their association as correlates with either behaviour although gender (male) is consistently positively associated with adolescents' physical activity.¹⁶⁻¹⁹ Regarding the factors of interest in the present study and their association with a change in adolescents' physical activity, one systematic review on 'determinants of change' has specifically summarised longitudinal studies in this area.²⁰ This review summarised that ethnicity (white Caucasian) is not associated and that the evidence is indeterminate for gender (male) and socioeconomic status. Area of residence, school type and educational attainment were not reported in this review due to no identified longitudinal studies. Another review summarised 'determinants' of adolescents' physical activity and sedentary behaviour (e.g., screen viewing) in longitudinal studies but did not focus specifically on factors associated with changes.²¹ Regarding the factors of interest in the present study and their association with a change in adolescents' sedentary behaviour (screen viewing), evidence is sparse due to a lack of longitudinal studies.²¹

What this study adds

Firstly, the longitudinal decline in adolescents' physical activity during this transitional period has not been previously confirmed in the UK, and thus provides further insight into this area of research and builds on previous UK longitudinal studies showing a decline in adolescents' physical activity prior to this transitional point.⁴¹ Secondly, the finding that females were less likely than males to decline in their physical activity contradicts the majority of studies which have concluded that female adolescents' physical activity declines more than male adolescents' physical activity^{37,40} Finally, this study has highlighted the large number of adolescents who were not meeting

guidelines for physical activity or screen time at either time point thus the high levels of physical inactivity and screen time of adolescents through this transition; a finding that has not been reported in the UK to date. Although all of these findings highlight the necessity to tackle physical inactivity and screen time use during the period of adolescence studied, intervention is needed before adolescence in order to halt the decline in physical activity in late-adolescence. Despite no associations being found for the other intrapersonal and environmental factors and the change in physical activity, some of these factors have rarely been studied before, especially in relation to a longitudinal change in adolescents' physical activity, thus this contributes to the existing limited evidence base.

Limitations of this study

Social desirability and self-report bias were a main limitation whereby participants possibly over/under-reported their amount of physical activity or screen time. Consequently, in over-reporting physical activity or under-reporting screen time, compliance with recommended guidelines could be lower than reported. To limit social desirability bias, the researcher explained to participants at baseline, where possible in the school setting, that they were not being assessed or tested on the basis of their responses. Seasonality was possibly a limitation as there is seasonal variation in physical activity with the lowest physical activity levels among adolescents reported to be in the winter season and higher levels in the summer season.⁵²⁻⁵⁵ In the present study, baseline data was collected between March and May (Spring season) and follow-up data was collected between September and December (Autumn season) and consequently there is relative comparability. Despite the possibility that seasonality was a limitation, there was no consistent message from the literature suggesting that it was necessary to design the study to control for the factor of season. Additionally, the period in which these data were collected was determined by school-term structures and in order to ensure that data collection timing was appropriate to capture the transition being studied. Finally, although data was collected from schools at baseline and follow-up, the resulting clustering of observations was not taken into account as each participant regardless of school attended was analysed as the unit of interest. Overall, strengths of this study include the longitudinal design as physical activity and screen time were able to be monitored over a period of time thus identifying if there were significant

changes in each behaviour during this transitional period. Secondly, having achieved a final sample size (for analysis) that comprised 30% (A1) and 37.8% (A2) of the original baseline cohort is a significant strength. Thirdly, there was sufficient power to detect important associations having performed a sample size assumption checking test.

Acknowledgements

We would like to thank participants who took part in the study and staff at each of the schools for their co-operation. Special thanks to John Stevens and Rhiannon Wright at Active Gloucestershire.

References

- 1 Townsend N, Wickramasinghe K, Scarborough P, Foster C, Rayner M. *Physical activity statistics 2012*. London: British Heart Foundation, 2012.
- 2 Department of Health. *Start Active, Stay Active: A report on physical activity from the four home countries' Chief Medical Officers*. London: Department of Health, 2011.
- 3 Olds TS, Maher CA, Ridley K, Kittel, DM. Descriptive epidemiology of screen and non-screen sedentary time in adolescents: a cross-sectional study. *Int J Behav Nutr Phys Act* 2010;**7**:92
- 4 American Academy of Pediatrics. Policy statement/Committee on Public Education. Children, adolescents, and television. *Pediatrics* 2001;**107**:423-6.
- 5 Australian Government Department of Health and Ageing. Australia's Physical Activity Recommendations for Children and Young People, 2005. <http://www.health.gov.au/internet/main/publishing.nsf/Content/health-publth-strateg-active-recommend.htm> (10 May 2013, date last accessed)
- 6 Canadian Society for Exercise Physiology. *Canadian Physical Activity Guidelines and Canadian Sedentary Behaviour Guidelines – Your Plan to Get Active Every Day*. Ontario: Canadian Society for Exercise Physiology, 2012.

- 7 Oehlschlaeger MHK, Pinheiro RT, Horta B, San'Tana GEP. Prevalence of sedentarism and its associated factors among urban adolescents. *Rev Saude Publica* 2004;**38**:1-6.
- 8 Bibiloni MDM, Pich J, Cordova A, Pons A, Tur JA. Association between sedentary behaviour and socioeconomic factors, diet and lifestyle among the Balearic Islands adolescents. *BMC Public Health* 2012;**12**:718.
- 9 Koezuka N, Koo M, Allison KR *et al*. The relationship between sedentary activities and physical inactivity among adolescents: results from the Canadian Community Health Survey. *J Adolesc Health* 2006;**39**:515-22.
- 10 Loucaides CA, Jago R, Theophamus M. Physical activity and sedentary behaviours in Greek-Cypriot children and adolescents: a cross-sectional study. *Int J Behav Nutr Phys Act* 2011;**8**:90.
- 11 Gebremariam MK, Bergh IH, Andersen LF *et al*. Are screen-based sedentary behaviors associated with dietary behaviors and leisure-time physical activity in the transition into adolescence?. *Int J Behav Nutr Phys Act* 2013;**10**:9.
- 12 The Sedentary Behaviour and Obesity Expert Working Group. *Sedentary Behaviour and Obesity: Review of the Current Scientific Evidence*. London: Department of Health and Department for Children, Schools and Families, 2010.
- 13 Caspersen CJ, Pereira MA, Curran KM. Changes in physical activity patterns in the United States, by sex and cross-sectional age. *Med Sci Sports Exerc* 2000;**32**:1601-09.
- 14 National Institute for Health and Clinical Excellence. *NICE public health guidance 6 - Behaviour change at population, community and individual levels*. London: National Institute for Health and Clinical Excellence, 2007.

- 15 World Health Organization. *Global Recommendations on Physical Activity for Health*. Geneva, Switzerland: World Health Organization, 2010.
- 16 Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. *Med Sci Sports Exerc* 2000;**32**:963-75.
- 17 Biddle SJH, Whitehead SH, O'Donovan TM, Nevill ME. Correlates of participation in physical activity for adolescent girls: a systematic review of recent literature. *J Phys Act Health* 2005;**2**:423-34.
- 18 Van der Horst K, Paw MJCA, Twisk JWR, Van Mechelen W. A brief review on correlates of physical activity and sedentariness in youth. *Med Sci Sports Exerc* 2007;**39**:1241-50.
- 19 Ferreira I, Van der Horst K, Wendel-Vos W, Kremers S, Van Lenthe FJ, Brug J. Environmental correlates of physical activity in youth - a review and update. *Obes Rev*, 2006;**8**:129-54.
- 20 Craggs C, Corder K, van Sluijs EMF, Griffin SJ. Determinants of change in physical activity in children and adolescents – a systematic review. *Am J Prev Med* 2011;**40**:645-58.
- 21 Uijtdewilligen L, Nauta J, Singh AS *et al*. Determinants of physical activity and sedentary behaviour in young people: a review and quality synthesis of prospective studies. *Br J Sports Med* 2011;**45**:896-905.
- 22 Biddle SJH, Atkin AJ, Cavill N, Foster C. Correlates of physical activity in youth: a review of quantitative systematic reviews. *Int Rev Sport Exerc Psychol* 2011;**4**:25-49.
- 23 Bauman AE, Reis RS, Sallis JF *et al*. Correlates of physical activity: why are some people physically active and others not?. *Lancet* 2012;**380**:258-71.

- 24 Sterdt E, Liersch S, Walter U. Correlates of physical activity of children and adolescents: A systematic review of reviews. *Health Educ J* 2013; doi:10.1177/00117896912469578
- 25 Gorely T, Marshall SJ, Biddle SJH. Couch kids: correlates of television viewing among youth. *Int J Behav Med* 2004;**11**:152-63.
- 26 Pate RR, Mitchell JA, Byun W, Dowda M. Sedentary behaviour in youth. *Br J Sports Med* 2011;**45**:906-13.
- 27 Sallis JF, Owen N. Ecological models of health behaviour. In: *Health Behaviour and Health Education: Theory, Research and Practice* (3rd edn.), 2002 (edited by K Glanz, BK Rimer and FM Lewis), 462-84. San Francisco: Jossey-Bass.
- 28 Pereira MA, FitzGerald SJ, Gregg EW *et al.* A collection of physical activity questionnaires for health-related research: Modifiable Activity Questionnaire for Adolescents. *Med Sci Sports Exerc* 1997;**29**:S79-S82.
- 29 Aaron DJ, Kriska AM, Dearwater SR *et al.* The epidemiology of leisure physical activity in an adolescent population. *Med Sci Sports Exerc* 1993;**25**:847-53.
- 30 Aaron DJ, Kriska AM, Dearwater SR, Cauley JA, Metz KF, LaPorte RE. Reproducibility and validity of an epidemiologic questionnaire to assess past year physical activity in adolescents. *Am J Epidemiol* 1995;**142**:191-201.
- 31 Department of Health. *At Least Five a Week: Evidence on the Impact of Physical Activity and its Relationship to Health. A Report from the Chief Medical Officer.* London: Department of Health, 2004.
- 32 Peduzzi P, Concato J, Kemper E, Holford TR, Feinstein AR. A simulation study of the number of events per variable in logistic regression analysis. *J Clin Epidemiol* 1996;**49**:1373-79.

- 33 Townsend P, Phillimore P, Beattie A. *Health and Deprivation: Inequality and the North*. Bristol: Croom Helm, 1988.
- 34 Bibby P, Shepherd J. *Developing a New Classification of Urban and Rural Areas for Policy Purposes: The Methodology*. London: Department for Rural Affairs, Office of the Deputy Prime Minister, Office for National Statistics, Welsh Assembly Government and Countryside Agency, 2004.
- 35 Allison KR, Adlaf EM, Dwyer JJM, Lysy DC, Irving HM. The decline in physical activity among adolescent students: a cross-national comparison. *Can J Public Health* 2007;**98**:97-100.
- 36 Thibault H, Contrand B, Saubusse E, Baine M, Maurice-Tison S. Risk factors for overweight and obesity in French adolescents: physical activity, sedentary behavior and parental characteristics. *Nutrition* 2010;**26**:192-200.
- 37 Dovey SM, Reeder AI, Chalmers DJ. Continuity and change in sporting and leisure time physical activities during adolescence. *Br J Sports Med* 1998;**32**:53-7.
- 38 Aarnio M, Winter T, Peltonen J, Kujala U, Kaprio J. Stability of leisure-time physical activity during adolescence: a longitudinal study among 16-, 17- and 18 year-old Finnish youth. *Scand J Med Sci Sports* 2002;**12**:179-85.
- 39 Kahn JA, Huang B, Gillman MW *et al*. Patterns and determinants of physical activity in U.S. adolescents. *J Adolesc Health* 2008;**42**:369-77.
- 40 Sagatun A, Kolle E, Anderssen SA, Thoresen M, Sogaard AJ. Three-year follow-up of physical activity in Norwegian youth from two ethnic groups: associations with socio-demographic factors. *BMC Public Health* 2008;**8**:419.
- 41 Henning Brodersen N, Steptoe A, Boniface DR, Wardle J. Trends in physical activity and sedentary behaviour in adolescence: ethnic and socioeconomic differences. *Br J Sports Med* 2007;**41**:140-4.

- 42 Butcher K, Sallis JF, Mayer JA, Woodruff S. Correlates of physical activity guideline compliance for adolescents in 100 U.S. Cities. *J Adolesc Health* 2008;**42**:360-8.
- 43 Li M, Dibley MJ, Sibbritt DW, Zhou X, Yan H. Physical activity and sedentary behavior in adolescents in Xi'an City, China. *J Adolesc Health* 2007;**41**:99-101.
- 44 Scully M, Dixon H, White V, Beckmann K. Dietary, physical activity and sedentary behaviour among Australian secondary students. *Health Promot Int* 2007;**22**:236-45.
- 45 Ogunleye AA, Voss C, Sadercock GR. Prevalence of high screen time in English youth: association with deprivation and physical activity. *J Public Health (Oxf)* 2012;**34**:46-53.
- 46 Gorely T, Marshall SJ, Biddle SJ, Cameron N. The prevalence of leisure time sedentary behaviour and physical activity in adolescent girls: an ecological momentary assessment approach. *Int J Pediatr Obes* 2007;**2**:227-34.
- 47 Gorely T, Biddle SJ, Marshall SJ, Cameron N. The prevalence of leisure time sedentary behaviour and physical activity in adolescent boys: an ecological momentary assessment approach. *Int J Pediatr Obes* 2009;**4**:289-98.
- 48 Biddle SJ, Gorely T, Marshall SJ, Cameron N. The prevalence of sedentary behavior and physical activity in leisure time: a study of Scottish adolescents using ecological momentary assessment. *Prev Med* 2009;**48**:151-5.
- 49 Hamar P, Biddle S, Soos I, Takacs B, Huszar, A. The prevalence of sedentary behaviours and physical activity in Hungarian youth. *Eur J Public Health* 2010;**20**:85-90.

- 50 Aires L, Andersen LB, Mendonca D, Martins C, Silva G, Mota J. A 3-year longitudinal analysis of changes in fitness, physical activity, fatness and screen time. *Acta Paediat* 2010;**99**:140-4.
- 51 Ullrich-French SC, Power TG, Daratha KB, Bindler RC, Steele MM. Examination of adolescents' screen time and physical fitness as independent correlates of weight status and blood pressure. *J Sports Sci* 2010;**28**:1189-96.
- 52 Rifas-Shiman SL, Gillman MW, Field AE *et al.* Comparing physical activity questionnaires for youth: seasonal vs annual format. *Am J Prev Med* 2001;**20**:282-5.
- 53 Peiró-Velert C, Devís-Devís J, Beltrán-Carrillo J, Fox KR. Variability of Spanish adolescents' physical activity patterns by seasonality, day of the week and demographic factors. *EJSS (Champaign)* 2008;**8**:163-71.
- 54 Bélanger M, Gray-Donald K, O'Loughlin J, Paradis G, Hanley J. Influence of weather conditions and season on physical activity in adolescents. *Ann Epidemiol* 2009;**19**:180-6.
- 55 Carson V, Spence JC. Seasonal variation in physical activity among children and adolescents. *Pediatr Exerc Sci* 2010;**22**:81-92.