RESEARCH ARTICLE

Lack of Exercise of "Moderate to Vigorous" Intensity in People with Low Levels of Physical Activity Is a Major Discriminant for Sociodemographic Factors and Morbidity

José A. Serrano-Sánchez[1,2]*, Luis M. Bello-Luján[3], Juan M. Auyanet-Batista[4], María J. Fernández-Rodríguez[5], Juan J. González-Henríquez[6]

1. Department of Physical Education and Sport Sciences, University of Las Palmas de Gran Canaria, Las Palmas de Gran Canaria, Spain, **2.** Research Institute of Biomedical and Health Sciences (IUIBS), University of Las Palmas de Gran Canaria, Las Palmas de Gran Canaria, Spain, **3.** Directorate General of Public Health, Canary Island Health Service, Las Palmas de Gran Canaria, Spain, **4.** Department of Primary Health Care, Canary Islands Health Service, Las Palmas de Gran Canaria, Spain, **5.** Department of Clinic Pathobiology, University Hospital Dr. Negrín, Las Palmas de Gran Canaria, Spain, **6.** Department of Matemathics, University of Las Palmas de Gran Canaria, Las Palmas de Gran Canaria, Spain

*jose.serrano@ulpgc.es

Abstract

Introduction: The aim is to examine the differences between participation at low and zero moderate to vigorous physical activity (MVPA) in relation to their trends and associations with known socio-demographic and health factors. We hypothesised that the number of people at zero MVPA level could be rising despite a parallel increase in the population meeting the recommended MVPA level. We also hypothesised that graded associations of sociodemographic and health factors exist across MVPA levels.

Methods: Two independent population-based samples ($n=4320$ [2004] and $n=2176$ [1997]), were recruited with a stratified and random sampling procedure and interviewed at home by professional interviewers. The MVPA was assessed by validated questionnaire. The participants were classified into three MVPA levels: zero, low and recommended MVPA. The trend of each MVPA level was analysed with the standardized prevalence ratios. Correlates of low and zero MVPA levels were examined using multinomial logistic regression.

Results: The population at zero and recommended MVPA levels rose between 1997–2004 by 12% (95% CI, 5–20%) and 7% (95% CI, −4–19%) respectively, while the population at low MVPA level decreased. At zero MVPA level, associative

patterns were observed with sociodemographic and health factors which were different when compared to the population at low MVPA level.

Conclusions: Despite the slight increase of population meeting the recommended MVPA level, a higher trend of increase was observed at zero MVPA level. Both recommended and low MPVA levels increased their participation by absorbing participants from the low MVPA level. The sociodemographic profile of those with low MVPA was more similar to the population at recommended MVPA than at zero MVPA level. Methodological implications about the combination of light and moderate-intensity PA could be derived. The prevention of decline in actual low MVPA could change the trend of increase in the population at zero MVPA level, particularly among young adults.

Introduction

Lack of physical activity is a major health risk for premature mortality and chronic morbidity [1–3]. In accordance with its public importance, the promotion of physical activity has been employed as an international strategy to prevent chronic diseases, particularly cardiovascular and metabolic diseases [4]. At the present time, the minimum recommended standard of physical activity for the general adult population entails the accumulation of a total of 150 minutes per week (min/wk) of any type of physical activity at moderate or higher intensity (MVPA ≥3.5 MET) in sessions of a minimum of 10 minutes [5–6]. For vigorous intensity physical activity the recommendation is for at least 75 min/wk. Additional muscle-strengthening activities are also recommended to obtain health benefits [5]. For a healthy adult, the minimum recommended MVPA level is met by 30 minutes of brisk paced walking on 5 days/wk.

Historically, public health recommendations have focused on encouraging leisure time PA of at least moderate intensity and of a sufficient amount to lead to beneficial health outcomes. Participation at a level of intensity (MVPA), which induces at least a moderate increase in the respiratory rate, is important from a public health perspective. At this level of intensity an improvement in cardiorespiratory fitness is expected [7–8]. Cardiorespiratory fitness is one of the best predictors of longevity [1, 9] and lower morbidity [10–11].

Those below the recommended level of MVPA have usually been classified as inactive, sedentary or having a sedentary lifestyle [12–16]. However, there have been recent calls to standardize the semantic use of the term "sedentary", with suggestions that this term should be avoided when describing individuals or population and used to define behaviours ≤1.5 metabolic equivalents (METs) [17–18]. Instead of sedentary, inactive has been suggested as a standard term to describe individuals and population whose MVPA levels are insufficient. The rationale is that sedentary behaviour (≤1.5 METs) has been found to be associated independently of other PA types with diverse health outcomes such as

obesity [19–20], cardio-metabolic risk [21–22], breast cancer [23] and mortality from all causes [24].

The classification of individuals, rather than their different physical activity behaviours, into levels of physical activity is also of interest in the field of physical activity promotion by contributing to the identification of population subgroups at health risk, and by helping to develop better tailored intervention strategies for promoting MVPA in population. The recommended MVPA level has been widely used in epidemiological research as an operational definition to classify participants for the examination of population trends [25–30] and socio-demographic correlates of MVPA [31–35]. Unlike the agreement about what constitutes sedentary behaviour, there is no established definition of what constitutes an inactive person. The most commonly used operational definition of the inactive level is below MVPA recommended level, but other operational definitions have also been employed, including the absence of MVPA [3, 36–37], ratio of energy expenditure in MVPA/total physical activity (i.e.<10%) [14–15, 38] and total physical activity energy expenditure (i.e., <1.5 Kcal/day/kg, <10 METs-hour/week) [31, 39]. Consequently, classification as inactive frequently includes those who do participate in MVPA but below the recommended level and those whose energy expenditure is exclusively in light PA and sedentary behaviours with a total absence of MVPA.

A temporal trend of increase of population meeting MVPA guidelines has been reported in USA (1998–2005) [28], Sweden (1990–2007)[40], Denmark (1987–2005)[41], England (1991–2004) [26] and Spain (1995–2003) [29]. A complementary trend of a reduction in the inactive population has been reported in USA (1994–2004)[42], Canada (1994–2005)[39] and Finland (1972–1997)[43]. In Spain, some studies have found a reduction in the inactive population (1995–2005) using a definition which classified as inactive those below the MVPA recommended level [29]. However, this reduction in the inactive population could be masking a trend of increase in population abandoning the MVPA intensity. It is plausible that the proportion of the adult population meeting the MVPA recommended level increases with a concomitant increase of the proportion stopping MVPA intensity. Correlates for the population at zero MVPA level could also be different from those for the population at low MVPA level, but the two are often combined to define inactivity. There is little information about potential differences among the inactive population (those below recommended MVPA level) regarding the intensity of physical activity performed.

The purpose of the present study is to examine potential differences in correlates and temporal trends among the inactive population considering the intensity of the leisure time physical activity performed. This entails comparisons between the population with some MVPA but below the recommended MVPA level and those population at zero MVPA level. We hypothesize that the number of people at zero MVPA level could be rising in parallel with the population meeting the recommended MVPA level. Also, the intensity of the physical activity

performed could affect the consistency of graded relationships of known MVPA correlates with low and zero MVPA levels.

Methods

Sample and design

The data were obtained from two independent samples used in the Canary Islands Health Survey of 1997 ($n=2176$) and 2004 ($n=4320$). The adult participants were informed of the objectives and their oral consent requested. If the adult participants agreed, the interviewer was invited into their home to conduct the interview. Verbal consent was sufficient and all the interviews were recorded and analyzed anonymously. A codec-number was used to record the consent. Written consent for those under the required legal age were obtained from legal tutors present in the home. If no legal tutor was available a second visit was attempted. If no legal tutor was present in the second visit, another home was randomly selected in the same census tract. The bioethics committee of the Canary Islands Health Service approved the procedures. The surveys employed multi-stage sampling stratified by island, district, municipal size and socioeconomic level of the census tracts, with a proportional distribution by age group and sex [44]. In 2004, the number of interviews in the older female group was increased to obtain more precise results for this collective. The number of census tracts and dwellings per tract was estimated through a linear cost function and statistical precision [44]. The total number of census tracts/dwellings per tract was 180/25 (2004) and 109/20 (1997), giving a sampling error of $\pm 1.9\%$ (2004) and $\pm 2.8\%$ (1997) for estimation of the inactive population and taking into consideration the design effect [45]. Participants were interviewed at their homes by professional interviewers, who were trained in the application of the questionnaire, including specific questions of physical activity. When the selected participant was not at home another family member of the same profile and sex was interviewed in their place. If no other suitable family member was available a second visit was attempted. If a second visit was unsuccessful, the nearest available dwelling was chosen as an alternative. The data of 1997 and 2004 were acquired in the months of June, July and August.

Assessment of physical activity and covariables

To evaluate leisure time MVPA the questions used were taken from the CINDI (Countrywide Integrated Noncommunicable Diseases Intervention Programme) survey of the World Health Organisation [46]. The questionnaire included 3 questions: **1)** How much PA do you have during your leisure-time? (If it varies with the seasons, mention the group that best represents the average of the year) (a. In my leisure time I read, watch television and do things that do not require PA; b. In my leisure time I walk, ride a bicycle or move in other ways requiring PA for at least 4 hours a week. This includes walking, fishing and hunting, lighter

garden work and so on, but not going to and coming from work. c. In my leisure time I have PAs to maintain fitness, such as running, skiing, gymnastics, swimming, ball-games or doing heavy garden work or its equivalent; d. In my leisure time I train regularly, several days a week, for competitions in running, orienteering, ball-games or other physically heavy sports; **2)** How often do you do activities lasting at least 20–30 minutes that make you short of breath and perspire? (open-ended question in days per week), **3)** How long do your episodes of physical activity last? (open-ended question in minutes per day). Validation of these questions was tested using as criteria cardiorespiratory fitness (indirect VO_2 max) and several cardiovascular risk factors in 652 adults (20–59 years old) [47]. For cardiorespiratory fitness, correlations with the questions were between 0.20–0.36, similar to those found for other international physical activity questionnaires [48–49]. The PA-CINDI questionnaire also showed good sensitivity to express significant differences between three levels of MVPA (low, moderate and high) in cardiorespiratory fitness, diastolic blood pleasure, total cholesterol, high density lipoprotein cholesterol and smoking. Reliability of the physical activity questions used in our study was tested on 480 participants two year later to examine whether changes in physical activities were associated to changes in several criterion measures obtained by exercise and analytical tests, showing that those participants who had increased their physical activity level expressed significant increases in maximum work load, total performed work load, high density lipoprotein cholesterol and a decrease in triglycerides, total cholesterol, systolic blood pressure, time for restoration of pulse rate and blood pressure [47]. The participants of our study were classified according to recommended MVPA levels [5–6], and additionally those participants below the recommended level were segregated into two groups with and without MVPA. The cut-off points for the 3 MVPA levels used for this study were: *recommended MVPA* (MVPA ≥5 days/wk and at least 30 min/day), *low MVPA* (MVPA <5 days/wk or <30 min/day and ≥1 day/week) and *zero MVPA* (no MVPA per week).

The questionnaire included additional standardised questions to obtain sociodemographic data and information concerning health behaviour and chronic morbidities: age, sex, occupation, educational level, marital status, perceived health, smoking habit and perceived fitness. Table 1 shows the categories used in the analyses. Perceived fitness involved asking the participants to provide a self-assessment on a scale of 1 to 5 (from very bad to very good). This question was shown to be a good predictor of mortality in a long-term prospective study (1988–2001) [50]. Participants were considered to be suffering from high blood pressure, diabetes, cholesterol disorders or rheumatic pain when they reported that their doctor had diagnosed them as such. The number of accumulated morbidities was also calculated for each participant (zero, one, two and three or more).

Table 1. Characteristics of the participants in the Canary Islands Health Survey 1997–2004.

	1997 (n=2176)	2004 (n=4320)	
	% (95% CI) [d]	% (95% CI) [d]	p
Sex [% (95% CI)] [a]			
Female	51.9 (48.9–55.0)	57.8 (55.5–60.1)	.000
Male	48.2 (45.3–51.2)	42.3 (40.3–44.4)	.000
Age [% (95% CI)] [b]			
16–30	31.3 (29.0–33.7)	21.7 (20.3–23.1)	.000
31–45	28.0 (25.8–30.2)	30.2 (28.5–31.9)	.093
46–60	21.1 (19.1–23.0)	19.8 (18.4–21.1)	.217
> 60	19.8 (17.9–21.7)	28.6 (27.1–30.2)	.000
Age (mean ± SD)	42.5±18.5	47.5±18.8	.000
Level of Education [% (95% CI)] [c]			
Primary or lesser	66.5 (63.1–69.8)	67.5 (65.3–69.7)	.407
Secondary	24.4 (22.5–26.4)	24.7 (23.2–26.2)	.793
University	9.1 (7.8–10.3)	7.8 (7.1–8.5)	.067
Marital status [% (95% CI)] [c]			
Single	30.0 (27.9–32.1)	32.5 (30.8–34.1)	.179
Married/in partnership	58.2 (55.0–61.4)	53.3 (51.3–55.4)	.236
Separated/Widowed	11.8 (10.1–13.5)	14.2 (13.4–15.0)	.095
Occupational status [% (95% CI)] [c]			
In employment	46.3 (43.4–49.1)	47.9 (45.8–50.0)	.125
Unemployed	8.5 (7.4–9.7)	11.6 (10.7–12.4)	.029
Student	9.7 (8.6–10.8)	7.4 (6.7–8.1)	.000
Home care	21.7 (19.9–23.5)	14.2 (13.4–15.0)	.000
Pensioner, retired	13.8 (12.4–15.3)	19.0 (18.0–20.0)	.000
Perceived health [% (95% CI)] [c]			
Good or very good	67.0 (63.6–70.4)	68.7 (66.2–71.2)	.163
Fair	21.3 (19.4–23.1)	24.9 (23.7–26.0)	.001
Bad or very bad	11.2 (9.9–12.5)	5.9 (5.5–6.3)	.000
Smoking habit [% (95%CI)] [c]			
Non-smoker	65.0 (61.7–68.3)	68.6 (66.3–70.9)	.084
<10 cig./day	7.7 (6.6–8.7)	7.7 (7.0–8.3)	.657
10–19 cig./day	9.9 (8.6–11.1)	8.4 (7.7–9.1)	.082
≥20 cig./day	17.5 (15.7–19.2)	15.3 (14.2–16.4)	.256
Perceived fitness [% (95% CI)] [c]			
Good or very good	23.8 (21.8–25.8)	36.6 (34.8–38.3)	.000
Normal	55.7 (52.6–58.8)	46.1 (44.3–48.0)	.000
Bad or very bad	20.5 (18.7–22.3)	17.3 (16.3–18.3)	.000
Morbidity [% (95% CI)] [c]			
Cholesterol disorders	9.9 (8.8–11.0)	11.8 (11.1–12.5)	.000
High blood pressure	13.3 (11.9–14.8)	16.0 (15.0–16.9)	.000
Diabetes	5.3 (4.5–6.2)	6.8 (6.3–7.4)	.000
Rheumatic pain	20.6 (18.8–22.4)	19.5 (18.5–20.5)	.456
Number of morbidities [% (95% CI)] [c]			
Zero	58.0 (54.9–61.2)	57.8 (55.5–60.0)	.379

Table 1. Cont.

		1997 (*n*=2176)	2004 (*n*=4320)	
		% (95% CI) [d]	% (95% CI) [d]	*p*
	One	23.4 (21.5–25.4)	22.8 (21.5–24.1)	.581
	Two	12.3 (10.9–13.7)	11.2 (10.4–12.0)	.094
	Three or more	6.2 (5.3–7.2)	8.3 (7.7–8.9)	.000

[a]Standardised by age,
[b]Standardised by sex,
[c]Standardised by age and sex using the direct method with the Spanish population as the standard.
[d](95% CI) =95% Confidence Interval,
* *p* values for differences between 1997–2004.

Data analysis

To analyse the trend in each of the three MVPA levels, the standardised prevalence ratio (SPR) 2004/1997 by age and sex was used [51]. All trend analyses were standardised using the direct method, taking as the standard the age and gender structure of the Spanish population. The confidence intervals of the SPR were calculated following the procedure described by Rothman and Greenland [52].

Multinomial logistic regression was used to analyse the multivariate associations between the independent variables and the three MVPA levels. In this correlational study, the data from both surveys (1997 and 2004) were analysed jointly (*n*=6496), including the year as a confounding variable. The potential differences for leisure time MVPA between census tracts, districts and islands were tested with a multilevel analysis [53]. The variance partition coefficients for the estimations of "zero MVPA" (2.9%, *p*=0.176) and "low MVPA" (3.5%, *p*=0.086) were not significant at census tract level and fell as the level (district and island) rose. Design effect was <1.75 for zero and low MVPA levels, suggesting that a fixed effects analysis at the individual level was appropriate for the data structure [54–55].

The results of the multinomial logistic regression are reported in terms of odds ratios (OR), confidence interval (95% CI) and statistical significance (*p*-value). The results are presented in bivariate form and adjusted for prior covariate selection obtained by stepwise analysis. The final model was selected with significant contributions (*p*<0.05) of age, sex, survey year, educational level, smoking habit, perceived fitness and 2 morbidities (cholesterol disorders and diabetes). The perceived health variable was discarded from the final analysis due to its association with perceived fitness (*r*=0.41, *p*<0.05) and because it led to confusion in the results. In the final model, two other morbidities were included (high blood pressure and rheumatic pain) for their theoretical interest. The goodness-of-fit of the multivariate model was verified with Pearson's Chi-Square test (*p*=0.331), showing a correct fit of the model [56] with the 3 MVPA levels as dependent variable. The total percentage of correctly predicted cases was 62.5%. Data analyses were performed with the R statistical package [57] and the multinomial logistic regression module of the SPSS v.19 software package [58].

Results

[Table 1](#) shows the characteristics of the two samples. A slight increase can be observed in 2004 in high blood pressure, cholesterol disorders and diabetes sufferers, as well as in the number of those suffering from three or more morbidities, the unemployed, pensioners and those with perceived good fitness. The differences between the limits of the confidence intervals (95% CI) however were in general very slight. The other categories revealed no consistent differences after standardising for age and sex.

Trend of the MVPA levels

[Fig. 1](#) shows the prevalence of the three MVPA levels analyzed in the period for males, females and overall. Zero MVPA was predominant in both samples and for both sexes ([Fig. 1](#)). In 2004, the prevalence of adults at zero MVPA level reached 50% (95% CI, 48.1–51.9%) and was higher in women than men (52.3% and 47.7% respectively, $p<0.05$). A 12% increase in the number of adults at zero MVPA level was observed ($SPR=1.12$, 95% CI, 1.05–1.20) and the increase was higher in men vs. women (see [Table 2](#)). The number of adults at low MVPA level underwent a significant fall of 16% and 24% in women and men, respectively ($p<0.05$). The recommended MVPA level rose by 7%, though this result was not statistically significant ($SPR=1.07$, 95% CI, 0.96–1.19, [Table 2](#)).

Trend of the MVPA levels by sociodemographic group and health factors

[Table 2](#) shows the prevalence and trend of the three MVPA levels analyzed. Sixteen of the 36 sociodemographic and health categories examined at zero MVPA level revealed significant changes ([Table 2](#)), most of them as trends of increase particularly in men, students, 16–30 group, good perceived fitness, single and heavy smokers ($\geq$ 20 cigarettes/day). Only the retired category showed a significant reduction in participation at zero MVPA level. A complementary trend to that observed for the population at zero MVPA level was observed at low MVPA level. Nineteen sociodemographic and health groups showed a significant reduction in participation at that level (SPR between 0.63 and 0.83, $p<0.05$, [Table 2](#)). At the recommended MVPA level, only one category (retired) revealed a significant trend of increase.

Associations of the sociodemographic and health factors with the MVPA levels

[Table 3](#) shows the results of the multinomial logistic regression analyses for zero and low MVPA levels vs. recommended MVPA levels as reference. The rise in age and fall in level of education and perceived fitness were independently associated with a higher prevalence at zero vs. recommended MVPA level. In addition, women, heavy smokers, those who reported cholesterol disorders or diabetes and
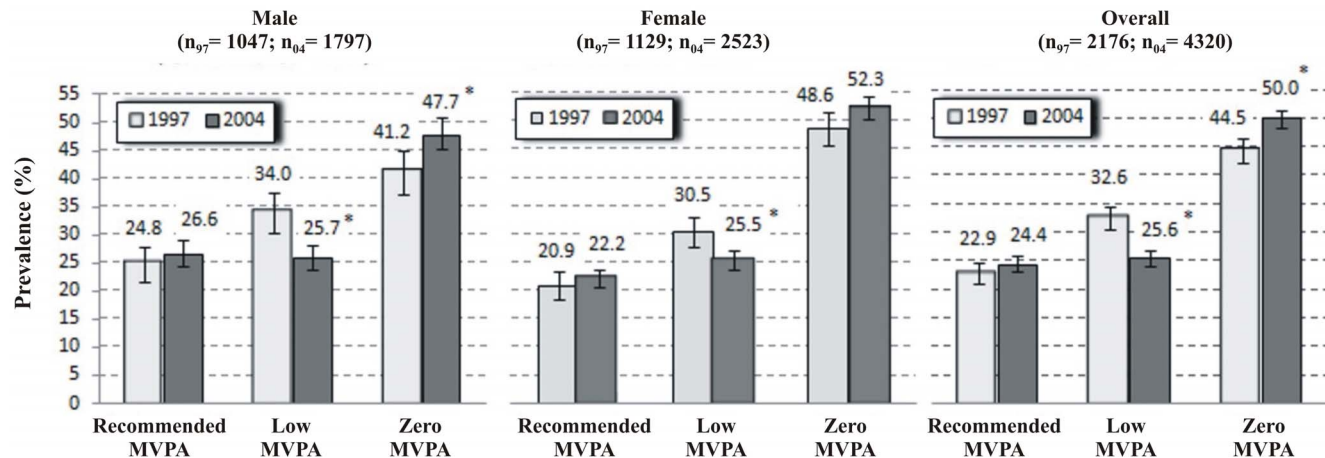
Fig. 1. Changes in the prevalence of moderate to vigorous physical activity levels by sex. Results of prevalence were standardized by age using the direct method. The error bars represent the 95% confidence interval.

those with three or more chronic conditions showed a higher probability of zero MVPA in their leisure time.

At low MVPA level, only perceived fitness and three or more morbidities continued to have the direct associations seen at zero MVPA level (Table 3). Of the remaining variables and categories, year and age showed an association with low MVPA that was the opposite of that seen with zero MVPA, while the associations for women, educational level, smoking, cholesterol disorders and diabetes were not observed at low MVPA level.

Discussion

This study was designed with the aim of examining differences among the inactive population at low and zero MVPA levels in relation with their trends and associations with sociodemographic factors, perceived physical fitness and some chronic morbidities. With respect to trends, the results showed that participation at zero MVPA and recommended MVPA levels rose over the study period whilst participation at low MVPA level decreased. The shift from the low MVPA level was mainly in the direction of zero MVPA and somewhat less in the direction of recommended MVPA level which was not significant. This trend suggests that monitoring the transition from low to zero MVPA level is a potential prevention strategy due to its capacity to reduce the numbers of those dropping out of the MVPA intensity and to increase the population at recommended MVPA level. Small increments in frequency and duration of MVPA among the population with low MVPA would increase the population at recommended MVPA level and reduce the population at zero MVPA level.

The intensity of the physical activity is important to obtain health benefits because at moderate or higher levels it activates relevant molecular mechanisms in

Table 2. Trend of moderate to vigorous physical activity levels according to selected characteristics.

	Recommended MVPA			Low MVPA			Zero MVPA		
	Prevalence		Trend	Prevalence		Trend	Prevalence		Trend
	1997	2004	SPR (95% CI) [a]	1997	2004	SPR (95% CI) [a]	1997	2004	SPR (95% CI) [a]
All									
%	22.9	24.4	1.07 (0.96–1.19)	32.6	25.6	**0.78 (0.71–0.84) ***	44.5	50.0	**1.12 (1.05–1.20) ***
N	497	1021	—	707	1045	—	972	2254	—
Sex									
Female	20.9	22.2	1.06 (0.91–1.24)	30.5	25.5	**0.84 (0.73–0.95) ***	48.6	52.3	1.08 (0.97–1.19)
Male	24.8	26.6	1.07 (0.92–1.25)	34.0	25.7	**0.76 (0.66–0.87) ***	41.2	47.7	**1.16 (1.03–1.30) ***
Age									
16–30	25.9	27.0	1.04 (0.86–1.27)	42.4	32.3	**0.76 (0.65–0.89) ***	31.6	40.7	**1.29 (1.09–1.52) ***
31–45	24.4	24.0	0.98 (0.81–1.20)	34.8	27.5	**0.79 (0.67–0.94) ***	40.9	48.6	**1.19 (1.03–1.38) ***
46–60	21.5	24.4	1.14 (0.89–1.45)	26.7	23.7	0.89 (0.71–1.11)	51.8	51.9	1.00 (0.85–1.17)
>60	17.6	21.5	1.22 (0.94–1.58)	20.0	15.0	0.75 (0.58–0.97)	62.4	63.5	1.02 (0.89–1.17)
Level of education									
Primary or lesser	22.0	23.7	1.08 (0.93–1.24)	29.0	22.2	**0.76 (0.67–0.87) ***	49.0	54.1	**1.11 (1.01–1.21) ***
Secondary	25.4	24.9	0.98 (0.77–1.26)	36.4	32.4	**0.89 (0.73–0.89) ***	38.2	42.7	1.12 (0.90–1.38)
University	28.9	31.8	1.10 (0.78–1.56)	38.7	27.6	**0.71 (0.52–0.97) ***	32.4	40.6	1.25 (0.92–1.71)
Marital status									
Single	23.6	24.3	1.03 (0.80–1.32)	36.7	26.6	**0.73 (0.59–0.89) ***	39.7	49.1	**1.24 (1.01–1.51) ***
Married/with partner	23.3	25.1	1.07 (0.92–1.26)	29.2	23.5	**0.80 (0.69–0.94) ***	47.5	51.4	1.08 (0.97–1.21)
Separated/widowed	19.4	24.0	1.24 (0.66–2.32)	25.5	18.0	0.70 (0.42–1.18)	55.1	58.1	1.05 (0.76–1.47)
Occupational status									
Student	33.1	29.3	0.89 (0.34–2.29)	49.5	30.6	0.62 (0.36–1.07)	17.4	40.1	**2.30 (1.18–4.51) ***
Unemployed	22.0	24.4	1.11 (0.62–1.96)	36.4	25.5	**0.70 (0.51–0.97) ***	41.6	50.1	1.21 (0.84–1.73)
Employed	23.9	23.6	0.99 (0.83–1.18)	34.3	26.6	**0.77 (0.66–0.91) ***	41.8	49.8	**1.19 (1.04–1.37) ***
Home care	22.9	23.3	1.02 (0.76–1.37)	25.2	21.7	0.86 (0.65–1.15)	51.9	55.0	1.06 (0.88–1.27)
Retired	9.5	24.5	**2.58 (1.61–4.13) ***	16.2	21.9	1.35 (0.77–2.37)	74.2	53.6	**0.72 (0.55–0.95) ***
Perceived health									
Good-very good	25.6	27.1	1.06 (0.94–1.20)	34.6	27.6	**0.80 (0.71–0.89) ***	39.8	45.2	**1.14 (1.03–1.26) ***
Fair	19.9	19.6	0.98 (0.73–1.32)	30.4	20.2	**0.67 (0.52–0.86) ***	49.7	60.2	**1.21 (1.03–1.43) ***
Bad-very bad	13.5	10.1	0.75 (0.37–1.51)	16.1	22.9	1.42 (0.77–2.63)	70.4	67.0	0.95 (0.71–1.28)
Smoking habit									
Non-smoker	24.0	25.2	1.05 (0.92–1.21)	33.3	27.5	**0.83 (0.73–0.94) ***	42.8	47.3	**1.11 (1.00–1.22) ***
<10 cig/day	26.5	24.7	0.93 (0.61–1.42)	31.6	29.3	0.93 (0.65–1.32)	41.8	46.0	1.10 (0.79–1.52)
10–19 cig/day	27.8	29.2	1.05 (0.72–1.52)	38.4	24.2	**0.63 (0.44–0.89) ***	33.8	46.6	1.16 (0.95–1.41)
≥20 cig/day	17.6	17.2	0.98 (0.67–1.42)	26.5	18.1	**0.68 (0.50–0.94) ***	55.9	64.7	**1.38 (1.02–1.87) ***
Perceived fitness									
Good-very good	37.1	34.0	0.92 (0.77–1.09)	35.4	29.7	0.84 (0.70–1.00)	27.4	36.2	**1.32 (1.08–1.61) ***
Normal	21.7	22.6	1.04 (0.89–1.22)	34.4	25.0	**0.73 (0.63–0.83) ***	43.9	52.4	**1.20 (1.07–1.33) ***
Bad-very bad	10.5	9.4	0.89 (0.57–1.38)	21.5	18.4	0.86 (0.62–1.18)	67.9	72.2	1.06 (0.91–1.24)
Chronic Morbidity									
Cholesterol disorders	14.3	16.5	1.15 (0.67–1.97)	41.8	26.7	0.64 (0.37–1.11)	43.9	56.8	1.29 (0.98–1.72)
High blood pressure	19.7	20.1	1.02 (0.63–1.65)	27.1	21.5	0.79 (0.49–1.27)	53.2	58.3	1.10 (0.82–1.47)
Diabetes	25.4	15.2	0.60 (0.19–1.89)	17.1	21.0	1.23 (0.53–2.84)	57.5	63.8	1.11 (0.62–2.00)

Table 2. Cont.

	Recommended MVPA			Low MVPA			Zero MVPA		
	Prevalence		Trend	Prevalence		Trend	Prevalence		Trend
	1997	2004	SPR (95% CI) [a]	1997	2004	SPR (95% CI) [a]	1997	2004	SPR (95% CI) [a]
Rheumatic pain	20.3	16.5	0.82 (0.54–1.24)	29.6	25.1	0.85 (0.56–1.29)	50.1	58.3	1.16 (0.94–1.44)
Number of morbidities									
Zero	24.2	27.3	1.13 (0.97–1.30)	31.6	26.1	**0.83 (0.73–0.94) ***	44.2	46.6	1.05 (0.94–1.18)
One	24.5	22.8	0.93 (0.73–1.18)	33.5	27.7	0.83 (0.67–1.02)	42.0	49.5	**1.18 (1.02–1.39) ***
Two	23.0	17.1	0.74 (0.46–1.21)	25.2	23.9	0.95 (0.60–1.51)	51.8	59.0	1.14 (0.87–1.49)
Three or more	19.2	14.2	0.74 (0.20–2.77)	21.4	24.4	1.14 (0.60–2.15)	59.4	61.4	1.03 (0.63–1.70)

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the oxidation of fatty acids and the transport of glucose to the interior of the muscle fibre [59–61]. Some of these mechanisms such as the activity of AMP-activated protein kinase may be altered in obese and diabetic patients [62–63], so moderate physical activity intensity could play a relevant role in the prevention of these chronic conditions. The monitoring of changes in population physical activity intensity is of interest in the field of physical activity promotion to obtain better results in interventions.

If MVPA intensity is contraindicated, the accumulation of time in light physical activity is a valid alternative to prevent the risk of inflammation in older adults [64] and improve their quality of life and physical health [65]. In healthy middle-aged adults, light physical activity measured by accelerometer has also been associated with an improvement in the 2-hr plasma glucose test [66]. In contrast, other longitudinal studies using questionnaires to assess physical activity have not found associations of light physical activity with a 10-year Framingham risk score [67] nor with the risk of mortality due to cardiovascular diseases, coronary heart disease or any other cause of mortality [68]. The dose of light physical activity for health benefits in the general population remains unclear. Light physical activity is seen as an alternative to moderate and higher intensity for special groups (e.g., dependents, older adults) and to mitigate the negative effect of sedentary behaviour on health in the general population [66, 69]. However, there are no specific standardised recommendations of how much light physical activity is good for health. The best option for general health improvement is to perform 150 min/week of moderate or higher-intensity activities [5] and reduce time in sedentary pursuits [70], including breaks in sedentary time [71].

The temporal trend of increase at zero MVPA level in our study was particularly observed in students and younger participants. It is coherent with the temporal trend observed in the population of Madrid (1995–2008) [36], and could be indicative of a change in young people's lifestyle. The decrease in walking, which is the most prevalent physical activity, has been proposed as an explanation of the rise in population with zero MVPA [36], but other explanations for younger people have been suggested including the rise in time given to sedentary

occupations [72–74], the increase in academic pressure [75] and out-of-school study time [76], and the accumulation of time in front of several screens [77].

In our study, 3 out of every 4 participants in 2004 were below the recommended MVPA level. This is in agreement with other European studies on the adult Spanish population which have reported corresponding values of between 68 and 74% [15, 78–79]. There exists strong evidence of a relationship of MVPA (negative) and of the accumulation of sitting time (positive) with the group of risk factors that comprise metabolic syndrome [80–81]. The low levels of MVPA in the Canary Islands could explain the high rate of metabolic syndrome found there [82], in fact we found an independent risk of having three or more chronic conditions for the population with zero MVPA.

The associations of low and zero MVPA levels with the sociodemographic and health variables were quite different when compared against the same reference (the recommended MVPA level). We observed that participation at zero MVPA level rose with age and survey year whereas participation at low MVPA level showed the opposite associations. In addition, sex, educational level, smoking habit and being diabetic displayed independent associations with zero MVPA but no association with low MVPA. The only two characteristics which showed significant associations in the same direction with both MVPA levels were perceived fitness and having 3 or more morbidities. This was contrary to what we expected for a graded association of the analyzed correlates across the 3 MVPA levels. In contrast, the profile of the population with low MVPA was more similar to that at the recommended MVPA level rather than to the population with zero MVPA, with the exceptions being for perceived fitness and the accumulation of 3 or more morbidities. This suggests that the intensity of PA performed among those at zero or low MVPA level tends to produce more qualitative or class differences instead of graded relationships. Practical implications in the operational definition of inactive could be derived because the low MVPA group could introduce noise in the associations with sociodemographic and health factors when it is combined together with the zero MVPA group to define the inactive category.

The absence of MVPA was significantly higher in those who reported cholesterol disorders, diabetes or having 3 or more chronic morbidities after adjusting for principal covariates. Bearing in mind these medical conditions had been diagnosed and prescribed for, these results would suggest the need for greater emphasis on prescribing MVPA in the health care of the chronically ill because those who are in most need of attaining the recommended MVPA level for health reasons are precisely those who are most strongly associated with a lifestyle absent of MVPA.

The present study has a number of limitations and strengths. The questionnaire as a data collection system is less precise than other objective methods, e.g., accelerometers, in terms of MVPA measurement. However, it is the most cost-effective method for the assessment of physical activity in large populations, enabling the estimation of patterns and trends with moderate validity and good reliability [83-84]. Grouping by levels helped to mitigate questionnaire MVPA

Table 3. Associations between levels of physical activity and selected sociodemographic and health characteristics.

	Zero MVPA (n=3226)				Low MVPA (n=1752)			
	Raw		Adjusted [a]		Raw		Adjusted [a]	
	OR[b]	(95%CI)	OR[b]	(95%CI)	OR[b]	(95%CI)	OR[b]	(95% CI)
Year								
1997	1		1		1		1	
2004	1.13	(1.03–1.25) *	1.28	(1.11–1.47) *	0.72	(0.62–0.83) *	0.78	(0.67–0.91) *
Sex								
Male	1		1		1		1	
Female	1.38	(1.22–1.56) *	1.20	(1.05–1.37) *	1.13	(0.98–1.29)	1.07	(0.92–1.23)
Age								
16–30	1		1		1		1	
31–45	1.37	(1.16–1.62) *	1.15	(0.94–1.41)	0.90	(0.75–1.07)	0.89	(0.74–1.06)
46–60	1.61	(1.34–1.93) *	1.19	(1.04–1.42) *	0.78	(0.64–0.96) *	0.75	(0.61–0.93) *
>60	2.26	(1.89–2.69) *	1.33	(1.08–1.65) *	0.59	(0.48–0.72) *	0.54	(0.43–0.69) *
Level of education								
University	1		1		1		1	
Secondary	1.27	(0.99–1.62)	1.39	(1.08–1.80) *	1.32	(1.03–1.70) *	1.27	(0.99–1.64)
Primary or lesser	2.05	(1.64–2.56) *	1.62	(1.28–2.05) *	0.93	(0.73–1.17)	0.95	(0.75–1.20)
Smoking habit								
Non smoker	1		1		1		1	
<10 cig/day	0.74	(0.60–1.05)	0.97	(0.77–1.22)	1.04	(0.81–1.33)	1.01	(0.78–1.31)
10–19 cig/day	0.80	(0.63–1.01)	0.99	(0.77–1.26)	0.93	(0.73–1.18)	0.88	(0.69–1.13)
≥20 cig/day	1.56	(1.30–1.87) *	1.92	(1.57–2.33) *	1.06	(0.85–1.31)	1.03	(0.83–1.29)
Perceived fitness								
Very good, good	1		1		1		1	
Normal	2.41	(2.10–2.76) *	2.23	(1.93–2.56) *	1.40	(1.21–1.62) *	1.45	(1.25–1.69) *
Bad, very bad	8.78	(7.04–10.93) *	7.24	(5.76–9.09) *	1.94	(1.51–2.50) *	2.20	(1.70–2.86) *
Morbidity								
Zero	1		1		1		1	
Cholesterol disorders	1.92	(1.56–2.36) *	1.45	(1.12–1.89) *	1.23	(0.97–1.56)	1.19	(0.95–1.51)
High blood pressure	1.63	(1.38–1.93) *	0.91	(0.75–1.11)	0.79	(0.64–1.03)	0.79	(0.63–1.00)
Diabetes	2.37	(1.81–3.10) *	1.49	(1.11–2.01) *	1.14	(0.83–1.58)	1.37	(0.97–1.94)
Rheumatic pain	2.05	(1.75–2.39) *	1.18	(0.99–1.42)	0.98	(0.82–1.19)	1.13	(0.91–1.39)
Number of morbidities								
Zero	1		1		1		1	
One	1.27	(1.09–1.48) *	0.99	(0.84–1.17)	1.05	(0.89–1.24)	1.16	(0.97–1.38)
Two	1.92	(1.58–2.34) *	1.18	(0.99–1.42)	0.92	(0.73–1.17)	1.07	(0.83–1.38)
Three or more	3.19	(2.48–4.11) *	1.69	(1.27–2.24) *	1.10	(0.81–1.50)	1.39	(1.05–1.94) *

Note: the reference category is the recommended MVPA level (n=1518).
[a]Adjusted for survey year, age, sex, educational level, perceived fitness and the four morbidities or alternatively the number of morbidities.
[b]OR = odds ratio by multinomial logistic regression.
* $p < 0.05$.

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overestimation [85], reducing classification errors. Another limitation is that cross-sectional studies do not allow the establishment of causality relationships, something that could be achieved with longitudinal or intervention designs. The prevalence of chronic morbidities in our study was an underestimation of actual prevalence [86–87], as it only evaluated morbidities known by participants aged 16 and over, with the focus being the MVPA levels of those whose medical condition had been diagnosed. One of the strengths of the study was the use of the same questions in the two surveys enabling control of one of the principal sources of variability in trend studies [88]. Also, the standardisation carried out using the national population as the standard facilitated its comparison with other studies that have been undertaken of the Spanish population. The stability of the weather conditions in the Canary Islands (year round temperatures of 18–24℃, 21 days of rain per year and 65–70% ambient humidity) ensured control of this potential source of variability, particularly in the physical activity of walking [89] which is the main contributor in recommended MVPA levels at population level [36,90].

Conclusions

Differences were observed between the temporal trends and correlates of the population at zero and low MVPA levels. An increase was observed over the study period in the population at zero MVPA level by a mechanism of transference from low MVPA level. Students and younger groups showed the greatest increase at zero MVPA level. The combination of zero and low MVPA in the same category, to define the inactive group, could be concealing the actual temporal trend of the population at zero MVPA level.

Zero and low MVPA also showed great differences for almost all examined correlates. Those with zero MVPA showed independent associations with age, sex, education, perceived fitness, heavy smokers, cholesterol disorders, diabetes and 3 or more morbidities, whilst those with low MVPA expressed opposite associations for age and no associations for sex, education, smoking and all separate chronic morbidities. Perceived fitness and 3 or more morbidities showed consistent and graded associations with the MVPA levels examined. The sociodemographic profile of those at low MVPA level was more similar to the recommended MVPA than the zero MVPA level. Methodological implications about the combination of PAs at different levels of intensity could be derived for separate verification of differences before combining light and moderate PA in epidemiological studies. Since the population at zero MVPA has a higher risk for some morbidities, it may be useful to identify those who might be at risk of decreasing PA or PA intensity to implement policies promoting PA for this specific sector of the population.

Acknowledgments

Author Contributions

Conceived and designed the experiments: JAS LMB JJG. Performed the experiments: JMA MJF JAS LMB. Analyzed the data: JAS JJG LMB JMA. Contributed reagents/materials/analysis tools: MJF JMA LMB. Wrote the paper: JAS LMB JMA MJF JJG.

References

1. **Schoenborn CA, Stommel M** (2011) Adherence to the 2008 adult physical activity guidelines and mortality risk. Am J Prev Med 40: 514–521.

2. **WHO** (2009) Global Health Risks. Mortality and burden of disease attributable to selected major risks. Geneve: World Health Organization Library.

3. **Reddigan JI, Ardern CI, Riddell MC, Kuk JL** (2011) Relation of physical activity to cardiovascular disease mortality and the influence of cardiometabolic risk factors. Am J Cardiol 108: 1426–1431.

4. **WHO** (2004) Global Strategy on Diet, Physical Activity and Health. Geneva: World Health Organization Library.

5. **WHO** (2010) Global recommendations on physical activity for health. Geneve: World Health Organization Library.

6. **U.S. Department of Health and Human Services** (2008) 2008 Physical Activity Guidelines for Americans. Atlanta, GA: US Departament of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion.

7. **Duncan GE, Anton SD, Sydeman SJ, Newton RL Jr, Corsica JA, et al.** (2005) Prescribing exercise at varied levels of intensity and frequency: a randomized trial. Arch Intern Med 165: 2362–2369.

8. **Nokes N** (2009) Relationship between physical activity and aerobic fitness. J Sports Med Phys Fitness 49: 136–141.

9. **Lee IM, Paffenbarger RS Jr** (2000) Associations of light, moderate, and vigorous intensity physical activity with longevity. The Harvard Alumni Health Study. Am J Epidemiol 151: 293–299.

10. **Tanasescu M, Leitzmann MF, Rimm EB, Willett WC, Stampfer MJ, et al.** (2002) Exercise type and intensity in relation to coronary heart disease in men. JAMA 288: 1994–2000.

11. **Churilla JR, Fitzhugh EC** (2012) Total physical activity volume, physical activity intensity, and metabolic syndrome: 1999–2004 National Health and Nutrition Examination Survey. Metab Syndr Relat Disord 10: 70–76.

12. **Tudor-Locke C, Craig CL, Thyfault JP, Spence JC** (2013) A step-defined sedentary lifestyle index: <5000 steps/day. Appl Physiol Nutr Metab 38: 100–114.

13. **Tremblay MS, Colley RC, Saunders TJ, Healy GN, Owen N** (2010) Physiological and health implications of a sedentary lifestyle. Appl Physiol Nutr Metab 35: 725–740.

14. **Cabrera de León A, Rodríguez-Pérez M, Rodríguez-Benjumeda LM, Anía-Lafuente B, Brito-Díaz B, et al.** (2007) Sedentary lifestyle: physical activity duration versus percentage of energy expenditure. Rev Esp Cardiol 60: 244–250.

15. **Varo JJ, Martinez-Gonzalez MA, De Irala-Estevez J, Kearney J, Gibney M, et al.** (2003) Distribution and determinants of sedentary lifestyles in the European Union. Int J Epidemiol 32: 138–146.

16. **Seefeldt V, Malina RM, Clark MA** (2002) Factors affecting levels of physical activity in adults. Sports Med 32: 143–168.

17. **Lynch BM, White SL, Owen N, Healy GN, Chadban SJ, et al.** (2010) Television viewing time and risk of chronic kidney disease in adults: the AusDiab Study. Ann Behav Med 40: 265–274.

18. **Sedentary Behaviour Research Network** (2012) Letter to the Editor: Standardized use of the terms ''sedentary'' and ''sedentary behaviours''. Appl Physiol Nutr Metab 37: 540–542.

19. **Sugiyama T, Healy GN, Dunstan DW, Salmon J, Owen N** (2008) Joint associations of multiple leisure-time sedentary behaviours and physical activity with obesity in Australian adults. Int J Behav Nutr Phys Act 5: 35.

20. **Liao Y, Harada K, Shibata A, Ishii K, Oka K, et al.** (2011) Joint associations of physical activity and screen time with overweight among japanese adults. Int J Behav Nutr Phys Act 8: 131.

21. **George ES, Rosenkranz RR, Kolt GS** (2013) Chronic disease and sitting time in middle-aged Australian males: findings from the 45 and Up Study. Int J Behav Nutr Phys Act 10: 20.

22. **Healy GN, Matthews CE, Dunstan DW, Winkler EA, Owen N** (2011) Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 2003-06. Eur Heart J 32: 590–597.

23. **Lynch BM, Friedenreich CM, Winkler EA, Healy GN, Vallance JK, et al.** (2011) Associations of objectively assessed physical activity and sedentary time with biomarkers of breast cancer risk in postmenopausal women: findings from NHANES (2003–2006). Breast Cancer Res Treat 130: 183–194.

24. **Katzmarzyk PT, Church TS, Craig CL, Bouchard C** (2009) Sitting time and mortality from all causes, cardiovascular disease, and cancer. Med Sci Sports Exerc 41: 998–1005.

25. **Carlson SA, Fulton JE, Schoenborn CA, Loustalot F** (2010) Trend and prevalence estimates based on the 2008 Physical Activity Guidelines for Americans. Am J Prev Med 39: 305–313.

26. **Stamatakis E, Ekelund U, Wareham NJ** (2007) Temporal trends in physical activity in England: the Health Survey for England 1991 to 2004. Prev Med 45: 416–423.

27. **Vandelanotte C, Duncan MJ, Caperchione C, Hanley C, Mummery WK** (2010) Physical activity trends in Queensland (2002 to 2008): are women becoming more active than men? Aust N Z J Public Health 34: 248–254.

28. **Chau J, Smith B, Chey T, Merom D, Bauman A** (2007) Trends in population levels of sufficient physical activity in NSW, 1998 to 2005: Summary report. Sidney: NSW Centre for Physical Activity and Health.

29. **Redondo A, Subirana I, Ramos R, Solanas P, Sala J, et al.** (2011) Trends in leisure time physical activity practice in the 1995–2005 period in Girona. Rev Esp Cardiol 64: 997–1004.

30. **Hallal PC, Knuth AG, Reis RS, Rombaldi AJ, Malta DC, et al.** (2011) Time trends of physical activity in Brazil (2006–2009). Rev Bras Epidemiol 14 Suppl 1: 53–60.

31. **Chen YJ, Huang YH, Lu FH, Wu JS, Lin LL, et al.** (2011) The correlates of leisure time physical activity among an adults population from southern Taiwan. BMC Public Health 11: 427.

32. **Cleland V, Ball K, Hume C, Timperio A, King AC, et al.** (2010) Individual, social and environmental correlates of physical activity among women living in socioeconomically disadvantaged neighbourhoods. Soc Sci Med 70: 2011–2018.

33. **King AC, Castro C, Wilcox S, Eyler AA, Sallis F, et al.** (2000) Personal and environmental factors associated with physical inactivity among different racial-ethnic groups of U.S. middle-aged and older-aged women. Health Psychol 19: 354–364.

34. **Brownson RC, Baker EA, Housemann RA, Brennan LK, Bacak SJ** (2001) Environmental and Policy Determinants of Physical Activity in the United States. Am J Public Health 91: 1995–2003.

35. **Hallal PC, Victora CG, Wells JC, Lima RC** (2003) Physical inactivity: prevalence and associated variables in Brazilian adults. Med Sci Sports Exerc 35: 1894–1900.

36. **Meseguer CM, Galan I, Herruzo R, Rodriguez-Artalejo F** (2011) Trends in leisure time and occupational physical activity in the Madrid region, 1995–2008. Rev Esp Cardiol 64: 21–27.

37. **Hayes DK, Fan AZ, Smith RA, Bombard JM** (2011) Trends in selected chronic conditions and behavioral risk factors among women of reproductive age, behavioral risk factor surveillance system, 2001–2009. Prev Chronic Dis 8: A120.

38. **Bernstein MS, Morabia A, Sloutskis D** (1999) Definition and prevalence of sedentarism in an urban population. Am J Public Health 89: 862–867.

39. **Juneau CE, Potvin L** (2010) Trends in leisure-, transport-, and work-related physical activity in Canada 1994–2005. Prev Med 51: 384–386.

40. **Ng N, Soderman K, Norberg M, Ohman A** (2011) Increasing physical activity, but persisting social gaps among middle-aged people: trends in Northern Sweden from 1990 to 2007. Glob Health Action 4: 6347.

41. **Petersen CB, Thygesen LC, Helge JW, Gronbaek M, Tolstrup JS** (2010) Time trends in physical activity in leisure time in the Danish population from 1987 to 2005. Scand J Public Health 38: 121–128.

42. **Kruger J, Ham SA, Kohl HW** (2005) Trends in leisure-time physical inactivity by age, sex, and race/ ethnicity - United States, 1994–2004 MMWR 54: 991–994

43. **Barengo NC, Nissinen A, Tuomilehto J, Pekkarinen H** (2002) Twenty-five-year trends in physical activity of 30- to 59-year-old populations in eastern Finland. Med Sci Sports Exerc 34: 1302–1307.

44. **ISTAC** (2004) Health survey of Canarias, 2004 Methology Encuesta de Salud de Canarias, 2004. Metodología. Las Palmas: Consejería de Sanidad.

45. **Bennett S, Woods T, Liyanage WM, Smith DL** (1991) A simplified general method for cluster-sample surveys of health in developing countries. World Health Stat Q 44: 98–106.

46. **WHO** (1995) Protocol and Guidelines. Countrywide Integrated Noncommunicable Diseases Intervention (CINDI) Programme. Copenhagen: WHO Regional Office for Europe

47. **Zabina EY, Muravov OI** (1995) Experience in Validation and Use of CINDI Physical Activity Questionnaire. Copenhagen: World Health Organization, WHO, Regional Office for Europe.

48. **Boon RM, Hamlin MJ, Steel GD, Ross JJ** (2010) Validation of the New Zealand Physical Activity Questionnaire (NZPAQ-LF) and the International Physical Activity Questionnaire (IPAQ-LF) with Accelerometry. Br J Sports Med 44: 741–746.

49. **Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, et al.** (2003) International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc 35: 1381–1395.

50. **Phillips AC, Der G, Carroll D** (2010) Self-reported health, self-reported fitness, and all-cause mortality: prospective cohort study. Br J Health Psychol 15: 337–346.

51. **Newman SC** (2001) Biostatistical Methods in Epidemiology. New York: John Wiley & Sons, Inc.

52. **Rothman KJ, Greenland S, Lash TL** (2008) Modern Epidemiology. Philadelphia, PA: Lippincott, Williams & Wilkins.

53. **Goldstein H** (1999) Multilevel Statistical Models. London: Institute of Education, Multilevel Models Project.

54. **Li F, Fisher KJ, Bauman A, Ory MG, Chodzko-Zajko W, et al.** (2005) Neighborhood influences on physical activity in middle-aged and older adults: a multilevel perspective. J Aging Phys Act 13: 87–114.

55. **Muthén B, Satorra A** (1995) Complex sample data in structural equation modeling. In: Marsden P, editor. Sociological methodology. Oxford, England: Blackwell. pp. 267–316.

56. **Tabatchnick BG, Fidell LS** (2007) Using multivariate statistics (5th ed.). Boston: Pearson Education Inc.

57. **R Core Team** (2012) R: A language and environment for statistical computing. Vienna, Austria R Foundation for Statistical Computing.

58. **IBM Corp.** (2010) Released 2010. IBM SPSS Statistics for Windows, Version 19.0. Armonk, NY: IBM Corp.

59. **Chen ZP, Stephens TJ, Murthy S, Canny BJ, Hargreaves M, et al.** (2003) Effect of exercise intensity on skeletal muscle AMPK signaling in humans. Diabetes 52: 2205–2212.

60. **Wojtaszewski JF, Nielsen P, Hansen BF, Richter EA, Kiens B** (2000) Isoform-specific and exercise intensity-dependent activation of 5'-AMP-activated protein kinase in human skeletal muscle. J Physiol 528 Pt 1: 221–226.

61. **Hardie DG** (2011) Sensing of energy and nutrients by AMP-activated protein kinase. Am J Clin Nutr 93: 891S–896.

62. **Steinberg GR, McAinch AJ, Chen MB, O'Brien PE, Dixon JB, et al.** (2006) The suppressor of cytokine signaling 3 inhibits leptin activation of AMP-kinase in cultured skeletal muscle of obese humans. J Clin Endocrinol Metab 91: 3592–3597.

63. **Ara I, Larsen S, Stallknecht B, Guerra B, Morales-Alamo D, et al.** (2011) Normal mitochondrial function and increased fat oxidation capacity in leg and arm muscles in obese humans. Int J Obes (Lond) 35: 99–108.

64. **Elosua R, Bartali B, Ordovas JM, Corsi AM, Lauretani F, et al.** (2005) Association between physical activity, physical performance, and inflammatory biomarkers in an elderly population: the InCHIANTI study. J Gerontol A Biol Sci Med Sci 60: 760–767.

65. **Buman MP, Hekler EB, Haskell WL, Pruitt L, Conway TL, et al.** (2010) Objective light-intensity physical activity associations with rated health in older adults. Am J Epidemiol 172: 1155–1165.

66. **Healy GN, Dunstan DW, Salmon J, Cerin E, Shaw JE, et al.** (2007) Objectively measured light-intensity physical activity is independently associated with 2-h plasma glucose. Diabetes Care 30: 1384–1389.

67. **Hu G, Jousilahti P, Antikainen R, Tuomilehto J** (2007) Occupational, commuting, and leisure-time physical activity in relation to cardiovascular mortality among finnish subjects with hypertension. Am J Hypertens 20: 1242–1250.

68. **Yu S, Yarnell JW, Sweetnam PM, Murray L** (2003) What level of physical activity protects against premature cardiovascular death? The Caerphilly study. Heart 89: 502–506.

69. **Healy GN, Wijndaele K, Dunstan DW, Shaw JE, Salmon J, et al.** (2008) Objectively measured sedentary time, physical activity, and metabolic risk: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). Diabetes Care 31: 369–371.

70. **Marshall SJ, Ramirez E** (2011) Reducing Sedentary Behavior: A New Paradigm in Physical Activity Promotion. AJLM 5: 518–530.

71. **Healy GN, Dunstan DW, Salmon J, Cerin E, Shaw JE, et al.** (2008) Breaks in sedentary time: beneficial associations with metabolic risk. Diabetes Care 31: 661–666.

72. **Gordon-Larsen P, Nelson MC, Popkin BM** (2004) Longitudinal physical activity and sedentary behavior trends: adolescence to adulthood. Am J Prev Med 27: 277–283.

73. **Nelson MC, Gordon-Larsen P, Adair LS, Popkin BM** (2005) Adolescent physical activity and sedentary behavior: patterning and long-term maintenance. Am J Prev Med 28: 259–266.

74. **Brodersen NH, Steptoe A, Boniface DR, Wardle J** (2007) Trends in physical activity and sedentary behaviour in adolescence: ethnic and socioeconomic differences. Br J Sports Med 41: 140–144.

75. **Pate RR, Davis MG, Robinson TN, Stone EJ, McKenzie TL, et al.** (2006) Promoting physical activity in children and youth: a leadership role for schools: a scientific statement from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism (Physical Activity Committee) in collaboration with the Councils on Cardiovascular Disease in the Young and Cardiovascular Nursing. Circulation 114: 1214–1224.

76. **Instituto de evaluación** (2009) Sistema estatal de indicadores de la educación. Madrid: Ministerio de Educación.

77. **Serrano-Sanchez JA, Marti-Trujillo S, Lera-Navarro A, Dorado-Garcia C, Gonzalez-Henriquez JJ, et al.** (2011) Associations between screen time and physical activity among Spanish adolescents. PLoS One 6: e24453.

78. **Sjöström M, Oja P, Hagströmer M, Smith BJ, Bauman A** (2006) Health-enhancing physical activity across European Union countries: the Eurobarometer study. J Public Health 14: 291–300.

79. **Rutten A, Abel T, Kannas L, von Lengerke T, Luschen G, et al.** (2001) Self reported physical activity, public health, and perceived environment: results from a comparative European study. J Epidemiol Community Health 55: 139–146.

80. **Ford ES, Kohl HW III, Mokdad AH, Ajani UA** (2005) Sedentary behavior, physical activity, and the metabolic syndrome among U.S. adults. Obes Res 13: 608–614.

81. **Pedersen BK, Saltin B** (2006) Evidence for prescribing exercise as therapy in chronic disease. Scand J Med Sci Sports 16: 3–63.

82. **Fernandez-Berges D, Cabrera de Leon A, Sanz H, Elosua R, Guembe MJ, et al.** (2012) Metabolic syndrome in Spain: prevalence and coronary risk associated with harmonized definition and WHO proposal. DARIOS study. Rev Esp Cardiol 65: 241–248.

83. **Shephard RJ** (2003) Limits to the measurement of habitual physical activity by questionnaires. Br J Sports Med 37: 197–206.

84. **Pols MA, Peeters PH, Kemper HC, Grobbee DE** (1998) Methodological aspects of physical activity assessment in epidemiological studies. Eur J Epidemiol 14: 63–70.

85. **Duncan GE, Sydeman SJ, Perri MG, Limacher MC, Martin AD** (2001) Can sedentary adults accurately recall the intensity of their physical activity? Prev Med 33: 18–26.

86. **Soriguer F, Goday A, Bosch-Comas A, Bordiu E, Calle-Pascual A, et al.** (2012) Prevalence of diabetes mellitus and impaired glucose regulation in Spain: the Di@bet.es Study. Diabetologia 55: 88–93.

87. **Cabrera de León A, Rodríguez Pérez MdC, Almeida González D, Domínguez Coello S, Aguirre Jaime A, et al.** (2008) Introducing the cohort "CDC Canary": objectives, design and preliminary results. Rev Esp Salud Pública 82: 1–16.

88. **Katzmarzyk PT, Tremblay MS** (2007) Limitations of data on physical activity in Canada: implications for monitoring trends. Appl Physiol Nutr Metab 32 Suppl 2F:: S206–216.

89. **Chan CB, Ryan DA** (2009) Assessing the effects of weather conditions on physical activity participation using objective measures. Int J Environ Res Public Health 6: 2639–2654.

90. **Serrano-Sanchez JA, Lera-Navarro A, Dorado-Garcia C, Gonzalez-Henriquez JJ, Sanchis-Moysi J** (2012) Contribution of individual and environmental factors to physical activity level among Spanish adults. PLoS One 7: e38693.