



Physical activity and health status among adolescents: a cross-sectional population-based study

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3 **Physical activity and health status among adolescents: a cross-sectional population-based**
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5 **study**
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Abstract

Objectives: Little is known about the dose-response relationship between physical activity and health benefits among young people. Our objective was to analyse the association between the frequency of undertaking Moderate-to-Vigorous Physical Activity (MVPA) and the health status of the adolescent population.

Design: Cross-sectional study.

Setting: All regions of Spain.

Participants: Students aged 11-18 years participating in the Spanish Health Behaviour in School-aged Children (HBSC) survey 2006. A total of 375 schools and 21,188 students were selected.

Main outcomes: The frequency of undertaking MVPA was measured, as were the following four health indicators: self-rated health, health complaints, satisfaction with life, and health-related quality of life. Linear and logistic regression models were used to analyse the association, adjusting for potential confounding variables and the modelling of the dose-response relationship.

Results: As the frequency of MVPA increased, the improvement in health benefits was greater. A linear trend ($p < 0.05$) was found for self-rated health and health complaints in males and females, and for satisfaction with life among females; for health-related quality of life, this relationship was quadratic for both sexes ($p < 0.05$). For self-reported health and health complaints, the effect was found to be of greater magnitude in males than in females and, in all scales, the benefits were observed from the lowest frequencies of MVPA, especially in males.

Conclusions: A protective effect of MVPA was found in both sexes for the four health indicators studied, and this activity had a gradient effect. Among males, health benefits were detected from

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very low levels of physical activity and the magnitude of the relationship was greater than that for females.

For peer review only

Article summary

Article focus

- Although it is recommended that all adolescents should undertake Moderate-to-Vigorous Physical Activity (MVPA) on most days of the week, little is known about the nature of the relationship in this population, and whether or not the effect varies depending on age and sex.
- We examined cross-sectional associations between the frequency of undertaking MVPA and the health status of the adolescent population, using subjective health scales that are considered to be useful tools especially in the stage of adolescence, when psychological aspects are so important in the feeling of well-being among young people.

Key messages

- The protective effect of MVPA on health was detected from very low levels, below those established by current recommendations.
- A linear trend was found for self-rated health, health complaints and for satisfaction with life. For health-related quality of life the relationship was quadratic.
- The positive effect on health produced lower results in females than in males.

Strengths and limitations of this study

- The main strength is the representativeness and large size of the sample. The methodology employed is the standard one for the HBSC study in which more than 40 Western countries have participated.
- A major limitation is the cross-sectional nature of the study. Moreover, the measurement of health status using subjective health scales and the estimation of MVPA are both based on self-reported information.

INTRODUCTION

According to the World Health Organization¹, physical inactivity is the fourth most important risk factor affecting global mortality, to which nearly 6% of all deaths are attributed. In the adolescent population, short-term benefits related to Physical Activity (PA) are improvements in lipid profile, blood pressure, metabolic syndrome, muscular strength and bone density, together with a reduction in obesity and overweight levels, as well as a decrease in emotional problems and depressive symptoms.²⁻⁵ Moreover, young people who undertake PA adopt healthy behaviour more easily and have better levels of academic achievement and cognitive functioning.^{4,6-8}

The dose-response relationship between physical activity and various health indicators has mainly been studied in the adult population,⁹⁻¹⁵ where there is still a controversy about whether or not this relationship is linear.^{12,16} Although it is recommended that all adolescents should undertake Moderate-to-Vigorous Physical Activity (MVPA) on most days of the week, little is known about the nature of the relationship in this population. Therefore, finding out the effect on health of several levels of PA could have important implications for improving the recommendations regarding this activity.

It should be emphasized that the special characteristics of adolescence require that measurement of health status must be approached from a global and comprehensive perspective for each individual. Concepts such as 'subjective health' and 'health-related quality of life' cover complex physical, emotional, mental and social aspects.^{17,18} Hence, it is important to evaluate if the effect of the PA is distributed in a distinct way for the different dimensions of health status.

Finally, although PA varies considerably depending on age and sex,¹⁹ to our knowledge there have been very few studies in the literature about the role that these variables play regarding the effect of PA on health.⁴

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3 The objective of this study was to analyse the association between the frequency of undertaking
4 MVPA and the different dimensions of adolescent health status, assessing if this relationship
5 differs according to age and sex.
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10 11 12 **METHODS**

13 14 **Study population**

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17 The source of information was the Health Behaviour in School-aged Children (HBSC) study
18 carried out in 2006.²⁰ The population was a representative sample of preadolescents and
19 adolescents, with an age range of 11-18 years, resident in Spain and enrolled in school from the
20 5th year of primary school to the last year of upper secondary school (2nd year of
21 baccalaureate). A multistage stratified random sampling was used, taking into account age
22 strata, region (autonomous community), school site (rural and urban), and type of school (public
23 and private). Initially, 480 schools were contacted of which 377 (103 private and 274 public
24 schools) agreed to participate in the study, which represented a response rate of 78.5%. A total
25 of 22,350 questionnaires were collected, although subsequently 539 were excluded because of
26 non-response to questions about sex and age, or lack of response to more than 50% of the
27 questionnaire. The sample size was 21,811 participants. The study was carried out in spring
28 2006. Previously trained survey technicians visited the selected schools, where the students
29 completed an anonymous questionnaire during normal school hours.
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47 **Study variables**

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50 Health status was measured using four indicators: 1) self-rated health was measured using the
51 question “*Would you say that your health is: excellent, good, fair or bad?*”. Optimal health status
52 was categorized by a response of excellent or good, and sub-optimal health status was
53 categorized by a response of fair or bad. 2) The health complaints indicator was assessed using a
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3 scale based on the HBSC-Symptom Checklist, which is a list of eight physical and psychological
4 symptoms (headaches, abdominal pain, backache, feeling low, irritability, nervousness, sleeping
5 difficulties and dizziness), to estimate their frequency during the last six months. Having 2 or
6 more symptoms with a frequency of several times a week or daily was considered to define
7 having noticeable subjective health complaints.¹⁷ 3) Satisfaction with life was estimated using
8 the Cantril Ladder,²¹ in which, using a scale from 0 to 10, the participant was asked “*on which*
9 *rung of the ladder (scale from 0 to 10) do you feel you stand at this moment in your life?*”, with 0
10 being the worst score and 10 the best. A score of 0 to 5 was categorized as dissatisfied, whereas a
11 score of 6 to 10 was categorized as satisfied.¹⁷ 4) Health-related quality of life was measured
12 using the Kidscreen-10 index,²² a series of 10 questions about mood, ability to concentrate,
13 energy, vitality, well-being, ability to have fun with friends. Each question has five categories of
14 response ranging from “never” to “always” or from “not at all” to “extremely often”. When using
15 this index the scores are calculated using T-values from a representative sample of the European
16 general population with a mean of 50 and a standard deviation of 1.
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34 The frequency of MVPA was measured using the question: “*in the last seven days, considering*
35 *moderate and vigorous activity... On how many days did you feel you were physically active for*
36 *a total of 60 minutes per day?*” The response categories were from 0 to 7 days.
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41 The following factors were considered as potentially confounding variables for the association
42 between health status and frequency of MVPA: 1) personal variables (sex, age, country of birth,
43 current smoker, alcohol consumption, body-mass index –calculated as the ratio of weight in
44 kg/height in m² from self-reported weight and height, and defining overweight and obesity using
45 the cut-off points proposed by Cole et al.,²³ consumption of fruit and vegetables, daily
46 breakfast, number of hours each day spent watching television and using computers or game
47 consoles, number of hours each day spent doing school homework); 2) family variables
48 (employment status of the father, employment status of the mother, family purchasing power –
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3 measured by the Family Affluence Scale,²⁴ an index estimated by four items: number of times
4 that the adolescents have been on holiday with their family in the last 12 months; does the family
5 own a car or van; does the student have his/her own bedroom; number of computers owned by
6 the family-, country of birth of the father, country of birth of the mother, type of household –both
7 parents, single parent, blended family–, number of minors in the household, number of adults in
8 the household); and 3) relationships with the school, the family and friends (academic
9 achievement, satisfaction with family relationships, satisfaction with relationships with friends).
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18 The variables are categorized in Table 1.
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20 21 **Data analysis**

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24 The questionnaires with missing values were excluded from data analysis, so that the number of
25 subjects studied was 17,467 for self-rated health; 17,358 for satisfaction with life; 16,803 for
26 health complaints; and 16,560 for health-related quality of life.
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31 The complex sampling design was taken into account during analysis by using the “Survey Data”
32 module of the statistical package Stata v11. Prevalence was calculated for optimal self-rated
33 health, low level of health complaints, high satisfaction with life, and the means for the scores on
34 the scale for health-related quality of life, with 95% confidence intervals, both global and for the
35 categories of each one of the exposure variables. Regression models were used, logistic ones for
36 the estimation of the odds ratio of prevalence (OR) and linear ones for the calculation of the
37 regression coefficients, adjusting for the potential confounding variables mentioned above. In
38 these models, statistical significance was set at $p < 0.05$.
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49 Linear and quadratic trends of the association between undertaking MVPA and the health
50 indicators were calculated from the regression models. For the linear trend, the average value for
51 each category was used modelling it as a continuous variable, while for the quadratic trend the
52 square of these values was used.
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3 To further explore the relationships between PA and health status indicators without imposing
4 any particular functional form for the dose-response trends, the amount of moderate-to-vigorous
5 physical activity was entered in regression models using restricted quadratic splines with knots at
6 1, 3.5, and 6 days/week.²⁵ Restricted quadratic splines allow for different quadratic trends within
7 each intermediate category and linear trends in boundary categories, and hence they can
8 accommodate a wide variety of smooth dose-response curves, while avoiding implausible shapes
9 at the tails of the exposure distribution.
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18 Interactions between MVPA, age and sex were evaluated. Given that interactions were found in
19 the relationship between the frequency of MVPA and health status according to sex, the results
20 are shown separately for males and females.
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28 RESULTS

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31 Table 1 describes the health status of the questionnaire respondents, as estimated by the four
32 health indicators. A total of 91.1% (CI 95%: 90.3-92.0) declared they had an optimal self-rated
33 health, 67.4% (CI 95%: 66.1-68.5) had a low level of health complaints and 90.9% (CI 95%:
34 90.1-91.6) reported a high satisfaction with life. The mean score on the scale for health-related
35 quality of life was 47.1 (CI 95%: 46.5- 47.6).
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43 According to all the indicators used, the level of health was better, in a statistically significant
44 way, for the questionnaire respondents who indicated that they undertook MVPA more
45 frequently, with gradual increases depending on the categories of PA (Table 1).
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50 No statistically significant interactions were found between MVPA and age, whereas statistical
51 significance was reached between MVPA and sex for the indicators self-rated health and
52 satisfaction with life.
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3 Tables 3 and 4 and Figure 1 show the results of the multivariate analysis that evaluated, for each
4 sex separately, the association of the frequency of undertaking MVPA with the different indicators
5 of health status, controlling the effect on this association of personal and family factors. For both
6 boys and girls, there was a positive, graded and statistically significant association (linear trend,
7 $p < 0.001$) between MVPA and self-rated health (Table 3), with odds ratios (OR) that ranged in
8 males from 2.37, for those who undertook MVPA on 1-2 days, to 4.60 and 4.05, for those
9 undertaking it on 5-6 and 7 days, respectively. Moving from less than 5 days to 5-6 days of MVPA,
10 the OR increased from 2.34 to 4.60. In females, although a positive association was also found, the
11 magnitude of the benefits on self-reported health was lower, with values that were half those for the
12 males (OR= 2.14, if MPVA undertaken 7 days).

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26 Regarding less health complaints (Table 3), an increase in the positive effects was seen in males
27 from small amounts of MVPA on 1-2 days (OR=1.66, $p=0.008$), which increased further to an OR
28 of nearly 2 for MVPA on 5-6 days. In females, this effect was lower, reaching statistical
29 significance after MVPA on 5-6 days with an OR of 1.46 ($p=0.009$). The linear trend p -value was
30 statistically significant ($p < 0.001$) in both males and females.

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The degree of satisfaction with life (Table 3) was also shown to be significantly associated with the
frequency of undertaking PA; among the boys the OR for high satisfaction increased to 1.99 if
physical activity was undertaken on 1-2 days per week, and satisfaction remained at these values
for frequencies of more than 5 days of MVPA. In girls, the magnitude of the effect was similar, but
the gradient was steeper. The linear trend p -value was statistically significant for females
($p < 0.001$), but not for males.

Table 4 shows the same analysis applied to health-related quality of life, considering it as a
continuous variable and using linear regression to analyse it. In males, an increasing dose-
response effect was seen, especially noticeable after 5-days per week of MVPA ($\beta=3.03$), which
increased even further, to 5.08, for those undertaking MVPA for 7-days per week. In females,

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3 the protective effect was lower at low levels of frequency of MVPA, but reached the same
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5 magnitude from 5 days of MVPA. Overall, this indicator was the one that showed fewer
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7 differences between boys and girls, as can be seen in Figure 1. The quadratic trend p-value was
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9 statistically significant in males ($p=0.006$) and females ($p<0.001$).
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12 13 14 15 **DISCUSSION**

16 17 18 **Principal findings**

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20 The results of this study clearly show the benefits of undertaking physical activity on the health
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22 status of adolescents enrolled in schools in Spain. The following results should be highlighted:
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24 1) the magnitude of the effect, with benefits on optimal health that reached OR higher than 4,
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26 for males who undertook MVPA daily or on most days, as compared to those who never
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28 undertook it; 2) the existence of a dose-response effect, with the positive effects increasing in
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30 accordance with the increase in the frequency of MVPA; 3) the consistency of the results with
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32 the association present for the four health indicators in both sexes; and 4) the greater positive
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34 effect in males, especially at low levels of frequency of MVPA.
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38 Few studies have linked the effect of MPVA on general indicators of health status in
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40 adolescents. Using data from the HBSC study for adolescents from North America, Western
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42 Europe, Eastern Europe, Northern Europe and Southern Europe, Iannotti et al.²⁶ evaluated the
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44 relationship between the frequency of PA and self-rated health, health complaints and
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46 satisfaction with life and found, as in our study, beneficial effects for all three indicators.
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49 50 **Dose-response relationship**

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52 The dose-response relationship between PA and health implies that increases in PA cause
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54 additional improvements in health status, even when it is not undertaken very frequently. This
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56 has also been found in other studies regarding dyslipidemia, blood pressure, overweight and
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3 obesity, metabolic syndrome and mental health.^{4,27-29} However, to our knowledge, there are no
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5 comparable studies that measure the nature of the relationship on general indicators of health
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7 status. Indeed, there is a controversy about whether this relationship is linear or curvilinear, as
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9 some studies have found linear patterns, whereas others have not,^{4,27-29} probably because the
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11 patterns can be different depending upon the health effect that is being assessed. In our study, a
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13 curvilinear relationship was found with a slight slowdown in the health benefits beyond 3-4
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15 days of MVPA in the following indicators: self-rated health; health complaints; and satisfaction
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17 with life. In contrast, for health-related quality of life in both sexes, the benefits increased from
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19 these intermediate levels of MVPA. These differences in the dose-response relationship suggest
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21 that the effect varies depending upon the different dimensions of health status to which the
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23 indicators are related. Although self-rated health has been proposed as a measurement of the
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25 summary effect of multiple dimensions of health, it is more closely related to the physical
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27 dimension rather than the mental and social ones.³⁰ Similarly, the scale for health complaints is
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29 related to symptoms with psychosomatic components very frequently associated with
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31 adolescence.³¹ Yet, the scale for the quality of life, besides including such physical and mental
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33 dimensions, also incorporates family and social relationships, which could suggest that these
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35 additional dimensions may be involved in the achieving of greater health benefits with the
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37 maximum frequencies of MVPA.
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44 It should be stressed that the benefits to health status are obtained from low levels of PA,
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46 especially for boys. Similar results have been reported for self-rated health in a young adult
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48 population³² and regarding blood pressure and dyslipidemia in adolescents.^{28,29} This could have
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50 important implications for the preventive recommendations because, although 60 minutes of
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52 physical activity is currently recommended (if possible on a daily basis), the fact that positive
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54 results of a moderate magnitude can be achieved with very small amounts of MVPA could
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56 encourage the participation of the more sedentary people.
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Gender differences

The results in health that are derived from undertaking MVPA are greater in males, especially in self-rated health and, to a lesser extent, in having less health complaints. According to our study, females need to undertake more days of MVPA to obtain similar health benefits. However, the effect on satisfaction with life and health-related quality of life was fairly similar in males and females. These differences suggest that the variation of the effect of MVPA according to sex could also be associated to different dimensions of health status. Previous reviews have clearly shown important differences between males and females in the quantity, intensity and type of physical activity, and that, in part, these distinctions could be explained by biological differences and those relating to sociocultural environment and body image^{19,33}. It would, therefore, be interesting for subsequent studies to undertake detailed research about this relationship.

Strengths and weaknesses

To aid correct interpretation of these data, several limitations should be mentioned. First, the limitation in causal inference, stemming from the cross-sectional nature of the study, would theoretically affect the temporality of the association. That is, people who have health problems can have limitations in undertaking physical exercise. However, from the data of the National Health Survey of 2006,³⁴ only 1.7% of adolescents between 16 and 19 years do not undertake the leisure time physical exercise that they would like to take because of health problems, hence, this figure would not affect the results obtained. Second, although it has shown an acceptable validation in our geographical coverage,³⁵ the measurement of MVPA is based (like several covariables of the study) on self-reported information and, therefore, it is not exempt from measurement bias. Third, it has not been possible to differentiate the effect of the intensity of physical activity, which is a dimension independently related with self-rated health.³²

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3 The main strengths of this study are the representativeness and large size of the sample used,
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5 which means that the results can be extrapolated accurately, and that the methodology employed
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7 is the standard one for the HBSC study. This is a collaborative WHO study in which more than
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9 40 Western countries (including Spain) have participated, so that our use of the standard
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11 methodology implies the comparability of our results at an international level. The measurement
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13 of health status using subjective health scales, as in this present study, has been validated in
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15 previous studies,^{18,21,22,36,37} and such scales are considered to be useful tools especially in the
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17 stage of adolescence, when psychological aspects are so important in the feeling of well-being
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19 among young people.
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26 CONCLUSIONS

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28 To sum up, an association was found between the frequency of undertaking MVPA and the
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30 health status of adolescents enrolled in schools in Spain. A linear trend was found for self-rated
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32 health, health complaints and for satisfaction with life. For health-related quality of life the
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34 relationship was quadratic. The protective effect of MVPA on health was detected from very
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36 low levels, below those established by current recommendations. In general, the effect on health
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38 produced lower results in females than in males, a finding that needs to be explained by
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40 subsequent research.
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48
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52 **Contributors:** All authors were involved in the development of the design of the study. PR, FR
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54 and CM coordinated the field work and collected the data. IG, RB, MM and RP conducted the
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3 analyses. IG and RB prepared the first draft. All authors contributed to the interpretation of data
4
5 and revision of the manuscript. All authors approved the final version.
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14 **Competing interests:** None.
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17 **Ethics approval:** This study was approved by the Institutional Review Board of the Carlos III
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19 Institute of Health.
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22 **Provenance and peer review:** Not commissioned; externally peer reviewed.
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25 **Data sharing statement:** Full results of the Spanish HBSC study are available at
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27 [http://www.msps.es/profesionales/saludPublica/prevPromocion/promocion/saludJovenes/estudi](http://www.msps.es/profesionales/saludPublica/prevPromocion/promocion/saludJovenes/estudioHBSC/nacional_hbsc.htm)
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Table 1. Description of the sample and distribution of optimal self-rated health, less health complaints, high satisfaction with life and health-related quality of life, according to individual variables. Spanish adolescents aged 11–18 years, 2006.

		Optimal Self-reported health		Less health complaints		High satisfaction with life		Health-related quality of life	
		N	%	N	%	N	%	N	Mean
MVPA	Global	17467	91.1	16803	67.4	17358	90.9	16560	47.1
	Never	1032	80.1*	1003	54.1*	1024	82.3*	985	42.6*
	1-2 days	4184	87.5	4007	62.8	4158	87.4	3958	44.3
	3-4 days	5592	90.8	5381	66.3	5561	91.3	5321	46.2
	5-6 days	3259	94.8	3139	72.8	3244	93.1	3105	48.2
Sex	7 days	3400	95.9	3273	74.1	3371	95.2	3191	52.5
	Male	8194	93.3*	7899	76.7*	8126	91.9*	7754	48.3*
Age	Female	9273	89.3	8904	59.5	9232	90.0	8807	46.1
	10-12	5168	95.8*	4838	68.6	5124	94.9*	4707	52.5*
	13-16	8852	90.1	8589	67.6	8796	89.8	8469	45.6
Born in Spain	17-18	3447	86.8	3376	65.1	3438	87.7	3385	43.2
	Yes	16323	91.1	15726	67.7*	16228	91.2*	15499	47.2
Smoking	No	1144	91.2	1077	62.9	1130	85.3	1062	45.7
	Non-smoker	11254	94.5*	10746	70.6*	11177	94.0*	10553	49.3*
	Smoker	2857	80.9	2799	56.6	2846	83.7	2780	42.8
Consumption of alcohol	Ex-smoker	3356	89.2	3258	66.6	3335	86.9	3228	44.1
	Never	7918	95.4*	7504	70.4*	7853	94.3*	7334	50.7*
	Rarely	3976	89.9	3842	65.2	3960	88.9	3802	45.4
	Monthly	2298	88.1	2243	66.3	2290	87.2	2240	43.5
Body-mass index	Weekly or daily	3275	85.2	3214	64.2	3255	87.9	3185	43.9
	Normal or underweight	12320	92.5*	11903	68.2*	12241	91.5*	11732	47.0
	Overweight	2264	86.7	2150	67.6	2247	90.3	2370	47.1
	Obese	348	77.4	329	58.0	349	83.0	325	46.6
Consumption of fruit and vegetables	NR	2535	90.4	2421	64.6	2521	89.4	2535	47.2
	Quartile 1	4786	88.2*	4597	64.1*	4754	88.8*	4521	45.8*
	Quartile 2	3698	91.5	3562	67.5	3676	91.5	3509	46.5
	Quartile 3	4302	92.5	4136	69.7	4276	92.2	4083	47.2
	Quartile 4	4681	92.6	4508	68.5	4652	91.2	4448	48.7
Breakfast during the week	Every day	12830	93.2*	12355	70.4*	12756	92.6*	12146	48.1*
	Not every day	4637	85.5	4448	59.1	4602	86.1	4415	44.3
Time spent TV and computers	Quartile 1	4001	91.1	3835	68.7*	3983	91.5*	4093	48.0*
	Quartile 2	4305	91.1	4136	69.4	4291	91.8	4109	47.0
	Quartile 3	4315	91.7	4185	68.8	4289	91.5	4315	47.0
	Quartile 4	4157	90.2	3997	62.8	4117	88.7	3956	46.2
	NR	689	92.6	650	65.4	678	89.3	628	48.6
Time spent studying/ homework	Quartile 1	3718	89.3*	3580	68.8*	3698	87.1*	3502	46.3*
	Quartile 2	3636	92.2	3485	69.3	3616	91.9	3431	47.9
	Quartile 3	5182	92.4	4979	68.8	5148	92.5	4936	47.7
	Quartile 4	4548	90.5	4399	62.9	4529	91.5	4347	46.3
	NR	383	89.4	360	69.3	367	88.6	345	48.4
Academic achievement	Very good	2809	96.3*	2692	71.8*	2796	96.4*	2644	52.4*
	Good	7375	94.0	7073	69.7	7327	94.2	6988	48.2
	Average	5847	87.4	5645	65.3	5811	87.3	5579	44.2
	Low	1436	79.7	1393	54.0	1424	75.3	1350	41.7

* $p < 0.05$

MVPA: Moderate-to-Vigorous Physical Activity

NR: Non-response

Table 2. Description of the sample and distribution of optimal self-rated health, less health complaints, high satisfaction with life and health-related quality of life, according to family variables. Spanish adolescents aged 11–18 years, 2006.

	Optimal Self-reported health		Less health complaints		High satisfaction with life		Health-related quality of life	
	N	%	N	%	N	%	N	Mean
Employment situation of father								
Paid employment	16187	91.5*	15581	67.8*	16089	91.3*	15364	47.2*
No paid employment	643	86.9	615	63.0	639	85.4	603	45.4
Don't know	79	90.3	74	52.9	78	91.5	73	43.3
No father	558	85.4	533	59.8	552	82.0	521	44.3
Employment situation of mother								
Paid employment	12355	91.0	11885	67.1	12274	90.8*	11706	47.1*
No paid employment	4940	91.5	4749	68.3	4911	91.4	4694	47.0
Don't know	48	90.9	47	59.1	48	91.4	44	47.5
No mother	124	83.7	122	58.7	125	78.0	117	45.2
Socioeconomic status								
Low	2552	86.2*	2450	62.6*	2537	84.5*	2403	45.2*
Average	8180	91.2	7876	66.7	8136	90.9	7731	46.9
High	6735	92.9	6477	69.9	6685	93.2	6427	48.0
Country of birth of father								
Spain	15941	91.1	15369	67.6	15854	91.2*	15160	47.1
Other countries	1526	91.1	1434	64.7	1504	86.2	1401	46.4
Country of birth of mother								
Spain	16161	91.1	15572	67.7*	16071	91.1*	15350	47.1
Other countries	1306	91.9	1231	62.4	1287	87.3	1211	46.1
Type of household								
Both parents	14773	92.0*	14238	68.4*	14684	91.9*	14016	47.3*
Single parent	1771	86.9	1690	62.2	1754	85.0	1674	45.7
Blended	587	83.0	562	59.3	587	82.6	556	44.2
Others	336	85.3	313	61.3	333	86.8	315	46.8
Number of adults in the household								
2	13606	91.7*	13606	64.1*	13521	91.2*	12912	47.3
0,1,3,4,5	3861	88.8	3861	68.3	3837	89.3	3649	46.4
Number of minors in the household								
1,2,3	16097	91.1	16097	60.3*	16008	91.0	15303	47.1
>3	1370	90.6	1370	68.0	1350	88.8	1258	46.8
Satisfaction: family relationships ^a								
Good	15537	93.0*	15537	45.2*	15442	94.2*	14722	48.0*
Fair-bad	1930	75.9	1930	70.1	1916	64.2	1839	39.4
Satisfaction: relationships with friends ^a								
Good	16412	92.0*	16412	48.5*	16310	92.3*	15560	47.5*
Fair-bad	1055	77.1	1055	68.6	1048	68.5	1001	40.0

* p<0.05

^a Good: score 7-10; Fair-bad: score 0-6

Table 3. Logistic models. Association between the amount of moderate-to-vigorous physical activity and optimal self-rated health, less health complaints and high satisfaction with life. Spanish adolescents aged 11–18 years, 2006.

	Males			Females	
	OR* (95% CI)	P		OR* (95% CI)	P
Optimal self-rated health					
Frequency of undertaking MVPA					
Never	1 (ref)			1 (ref)	
1-2 days	2.37 (1.56 to 3.58)	<0.001		1.20 (0.85 to 1.69)	0.282
3-4 days	2.34 (1.44 to 3.81)	0.001		1.51 (1.06 to 2.14)	0.020
5-6 days	4.60 (2.60 to 8.13)	<0.001		2.28 (1.47 to 3.52)	<0.001
7 days	4.05 (2.38 to 6.89)	<0.001		2.14 (1.37 to 3.34)	0.001
Linear trend P-value	<0.001			<0.001	
Quadratic trend P-value	0.325			0.850	
Less health complaints					
Frequency of undertaking MVPA					
Never	1 (ref)			1 (ref)	
1-2 days	1.66 (1.14 to 2.42)	0.008		1.16 (0.90 to 1.49)	0.226
3-4 days	1.65 (1.14 to 2.39)	0.007		1.21 (0.93 to 1.58)	0.143
5-6 days	2.09 (1.47 to 2.96)	<0.001		1.46 (1.10 to 1.93)	0.009
7 days	1.94 (1.38 to 2.73)	<0.001		1.32 (0.97 to 1.80)	0.076
Linear trend P-value	0.001			0.021	
Quadratic trend P-value	0.216			0.463	
High satisfaction with life					
Frequency of undertaking MVPA					
Never	1 (ref)			1 (ref)	
1-2 days	1.99 (1.20 to 3.31)	0.007		0.93 (0.63 to 1.36)	0.722
3-4 days	1.52 (0.90 to 2.55)	0.111		1.44 (0.99 to 2.10)	0.056
5-6 days	2.02 (1.17 to 3.49)	0.011		1.56 (0.98 to 2.49)	0.059
7 days	1.94 (1.09 to 3.44)	0.023		2.00 (1.19 to 3.35)	0.008
Linear trend P-value	0.128			<0.001	
Quadratic trend P-value	0.661			0.975	

* Adjusted for age, country of birth, smoking, alcohol consumption, BMI, consumption of fruit and vegetables, daily breakfast, time spent watching TV using computers, time spent studying, academic achievement, employment situation of the father and mother, socioeconomic status, country of birth of the father and mother, type of household, number of adults and number of minors in the household, satisfaction with family relationships and with friends.

Table 4. Linear models. Association between the amount of moderate-to-vigorous physical activity and health-related quality of life. Spanish adolescents aged 11–18 years, 2006.

	Males		Females	
	β * (95% CI)	P	β * (95% CI)	P
Frequency of undertaking MVPA				
Never	0 (ref)		0 (ref)	
1-2 days	1.61 (0.29 to 2.93)	0.017	0.19 (- 0.71 to 1.10)	0.676
3-4 days	1.87 (0.50 to 3.24)	0.007	1.19 (0.37 to 2.02)	0.005
5-6 days	3.03 (1.74 to 4.31)	<0.001	2.79 (1.76 to 3.82)	<0.001
7 days	5.08 (3.73 to 6.43)	<0.001	5.09 (3.86 to 6.32)	<0.001
Linear trend P-value	<0.001		<0.001	
Quadratic trend P-value	0.006		<0.001	

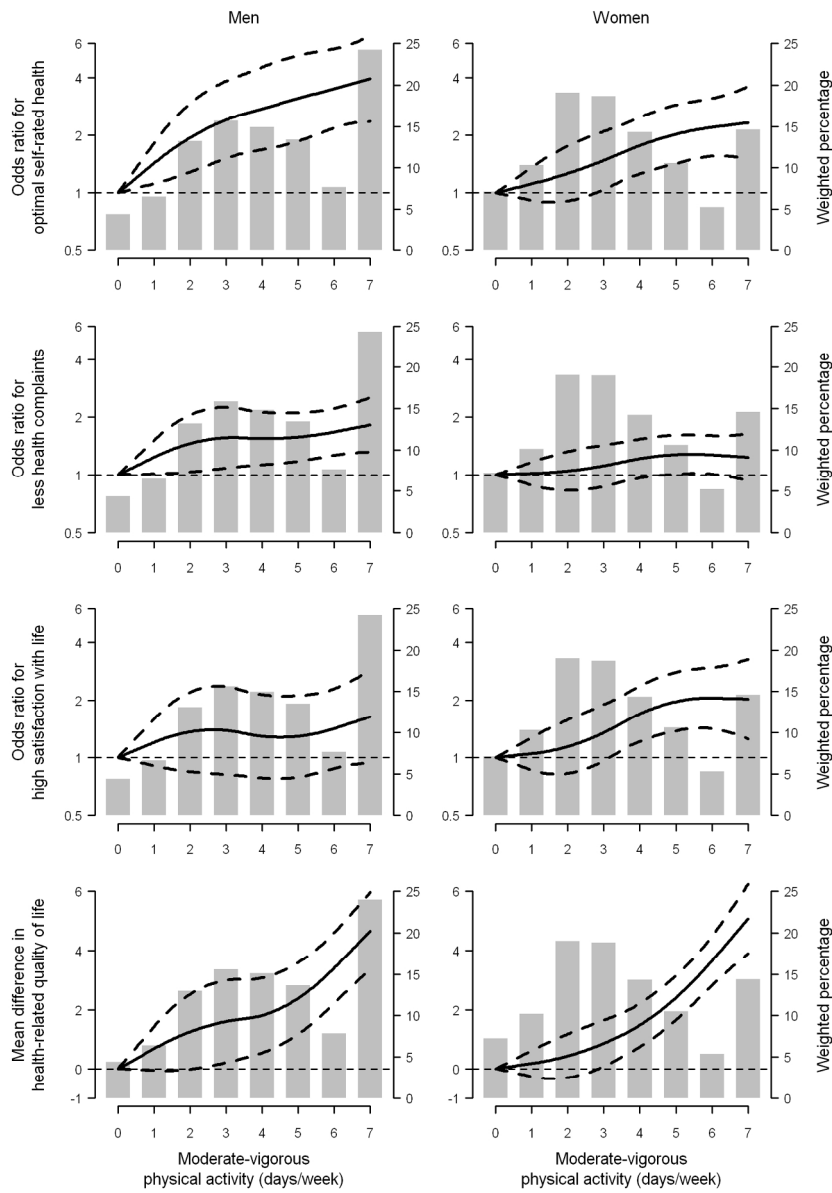
* Adjusted for age, country of birth, smoking, alcohol consumption, BMI, consumption of fruit and vegetables, daily breakfast, time spent watching TV and using computers, time spent studying, academic achievement, employment situation of the father and mother, socioeconomic status, country of birth of the father and mother, type of household, number of adults and number of minors in the household, satisfaction with family relationships and with friends.

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3 Figure 1. Dose-response relationship of the amount of Moderate-to-Vigorous Physical Activity
4 (MVPA) with optimal self-rated health, less health complaints, high satisfaction with life, and
5 health-related quality of life among Spanish adolescents aged 11–18 years.
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9 *Footnote:*

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11 Curves represent adjusted odds ratios or mean differences (solid lines) and their 95% confidence
12 intervals (dashed lines) based on restricted quadratic splines for the amount of MVPA with
13 knots at 1, 3.5, and 6 days/week. The reference value (odds ratio = 1 and mean difference = 0)
14 was set at 0 days/week of moderate-vigorous physical activity. Odds ratios and mean
15 differences were obtained from logistic and linear regression models accounting for the complex
16 survey and adjusted for personal and familial risk factors (see Methods). Bars represent the
17 weighted bar charts of the amount of MVPA among males and females.
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Physical activity and health status among adolescents: a cross-sectional population-based study

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3 **Physical activity and self-reported health status among adolescents: a cross-sectional**
4 **population-based study**
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Abstract

Objectives: Little is known about the dose-response relationship between physical activity and health benefits among young people. Our objective was to analyse the association between the frequency of undertaking Moderate-to-Vigorous Physical Activity (MVPA) and the self-reported health status of the adolescent population.

Design: Cross-sectional study.

Setting: All regions of Spain.

Participants: Students aged 11-18 years participating in the Spanish Health Behaviour in School-aged Children (HBSC) survey 2006. A total of 375 schools and 21,188 students were selected.

Main outcomes: The frequency of undertaking MVPA was measured by questionnaire, as were the following four health indicators: self-rated health, health complaints, satisfaction with life, and health-related quality of life. Linear and logistic regression models were used to analyse the association, adjusting for potential confounding variables and the modelling of the dose-response relationship.

Results: As the frequency of MVPA increased, the association with health benefits was stronger. A linear trend ($p < 0.05$) was found for self-rated health and health complaints in males and females, and for satisfaction with life among females; for health-related quality of life, this relationship was quadratic for both sexes ($p < 0.05$). For self-reported health and health complaints, the effect was found to be of greater magnitude in males than in females and, in all scales, the benefits were observed from the lowest frequencies of MVPA, especially in males.

Conclusions: A protective effect of MVPA was found in both sexes for the four health indicators studied, and this activity had a gradient effect. Among males, health benefits

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were detected from very low levels of physical activity and the magnitude of the relationship was greater than that for females.

For peer review only

Article summary

Article focus

- Although it is recommended that all adolescents should undertake 60 minutes of daily Moderate-to-Vigorous Physical Activity (MVPA), little is known about the nature of the relationship in this population, and whether or not the effect varies depending on age and sex.
- We examined cross-sectional associations between the frequency of undertaking self-reported MVPA and the health status of the adolescent population, using subjective health scales that are considered to be useful tools especially in the stage of adolescence, when psychological aspects are so important in the feeling of well-being among young people.

Key messages

- The protective effect of MVPA on health was detected from very low levels, below those established by current recommendations.
- A linear trend was found for self-rated health, health complaints and for satisfaction with life. For health-related quality of life the relationship was quadratic.
- The positive effect on health produced lower results in females than in males.

Strengths and limitations of this study

- The main strength is the representativeness and large size of the sample. The methodology employed is the standard one for the HBSC study in which more than 40 Western countries have participated.
- A major limitation is the cross-sectional nature of the study. Moreover, the measurement of health status using subjective health scales and the estimation of MVPA are both based on self-reported information.

INTRODUCTION

According to the World Health Organization (WHO)¹, physical inactivity is the fourth most important risk factor affecting global mortality, to which nearly 6% of all deaths are attributed. In the adolescent population, short-term benefits related to Physical Activity (PA) are improvements in lipid profile, blood pressure, metabolic syndrome, muscular strength and bone density, together with a reduction in obesity and overweight levels, as well as a decrease in emotional problems and depressive symptoms.²⁻⁵ Moreover, young people who undertake PA adopt healthy behaviour more easily and have better levels of academic achievement and cognitive functioning.^{4, 6-8}

The dose-response relationship between physical activity and various health indicators has mainly been studied in the adult population,⁹⁻¹⁵ where there is still a controversy about whether or not this relationship is linear.^{12,16} Ekelund et al.,¹⁷ in a pooled data analysis of 14 studies in children and adolescents, found a direct benefit between three tertiles of Moderate-to-Vigorous Physical Activity (MVPA) in relation to cardiometabolic outcomes. Although the WHO recommends that all children of 5-17 years of age take at least 60 minutes of daily MVPA,¹⁸ little is known about the nature of the relationship in this population. Therefore, finding out the effect on health of several levels of PA could have important implications for improving the recommendations regarding this activity.

It should be emphasized that concepts underlying health status in children and adolescents differ from those for adults. As young people are still developing, the measurement of health status must be approached from a global and comprehensive perspective for each individual. Concepts such as 'subjective health' and 'health-related quality of life' cover complex physical, emotional, mental and social aspects.^{19,20} Hence,

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2
3 it is important to evaluate if the effect of the PA is distributed in a distinct way for the
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5 different dimensions of health status.
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8 Finally, although PA varies considerably depending on age and sex,²¹ to our knowledge
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10 there have been very few studies in the literature about the role that these variables play
11
12 regarding the effect of PA on health.⁴
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15 The objective of this study was to analyse the association between the frequency of
16
17 undertaking MVPA and the different dimensions of adolescent health status, assessing if
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19 this relationship differs according to age and sex.
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22 23 24 25 **METHODS**

26 27 **Study population**

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30 The source of information was the Health Behaviour in School-aged Children (HBSC)
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32 study carried out in 2006.²² The population was a representative sample of
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34 preadolescents and adolescents, with an age range of 11-18 years, resident in Spain and
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36 enrolled in school from the 5th year of primary school to the last year of upper
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38 secondary school (2nd year of baccalaureate). A multistage stratified random sampling
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40 was used, taking into account age strata (4 groups), region (17 autonomous
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42 communities), school site (rural and urban), and type of school (public and private).
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44 Initially, 480 schools were contacted of which 377 (103 private and 274 public schools)
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46 agreed to participate in the study, which represented a response rate of 78.5%. On
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48 average, three classes were selected in each school. A total of 22,350 questionnaires
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50 were collected, although subsequently 539 were excluded because of non-response to
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52 questions about sex and age, or lack of response to more than 50% of the questionnaire.
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57 The sample size was 21,811 participants. The study was carried out in spring 2006.
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3 Previously trained survey technicians visited the selected schools, where the students
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5 completed an anonymous questionnaire during normal school hours.
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8 This study was approved by the Institutional Review Board of the Carlos III Institute of
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10 Health .
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12 13 **Study variables**

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15 Health status was measured using four indicators: 1) self-rated health was measured using
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17 the question “*Would you say that your health is: excellent, good, fair or bad*”. Optimal
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19 health status was categorized by a response of excellent or good, and sub-optimal health
20
21 status was categorized by a response of fair or bad. 2) The health complaints indicator
22
23 was assessed using a scale based on the HBSC-Symptom Checklist, which is a list of
24
25 eight physical and psychological symptoms (headaches, abdominal pain, backache,
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27 feeling low, irritability, nervousness, sleeping difficulties and dizziness), to estimate their
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29 frequency during the last six months. Having 2 or more symptoms with a frequency of
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31 several times a week or daily was considered to define having noticeable subjective
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33 health complaints.¹⁹ 3) Satisfaction with life was estimated using the Cantril Ladder,²³ in
34
35 which, using a scale from 0 to 10, the participant was asked “*on which rung of the ladder*
36
37 *(scale from 0 to 10) do you feel you stand at this moment in your life?*”, with 0 being the
38
39 worst score and 10 the best. A score of 0 to 5 was categorized as dissatisfied, whereas a
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41 score of 6 to 10 was categorized as satisfied.¹⁹ 4) Health-related quality of life was
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43 measured using the Kidscreen-10 index,²⁴ a series of 10 questions about mood, ability to
44
45 concentrate, energy, vitality, well-being, ability to have fun with friends. Each question
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47 has five categories of response ranging from “never” to “always” or from “not at all” to
48
49 “extremely often”. The items fulfil the assumptions of the Rasch model. To make the
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51 interpretation more applicable, the scores of the Rasch scales are translated into T-values
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3 with scale means of 50 and standard deviation of 10, with higher values indicating higher
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5 health-related quality of life.²⁴
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8 The frequency of MVPA was measured using the question: “*in the last seven days,*
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10 *considering moderate and vigorous activity... On how many days did you feel you were*
11 *physically active for a total of 60 minutes per day?*” The response categories were from 0
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13 to 7 days. This question, when compared with PA assessed by accelerometers in Spanish
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15 adolescents, has shown an acceptable validation.²⁵
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19 The following factors were considered as potentially confounding variables for the
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21 association between health status and frequency of MVPA: 1) personal variables (sex,
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23 age, country of birth, current smoker, alcohol consumption, body-mass index –calculated
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25 as the ratio of weight in kg/height in m² from self-reported weight and height, and
26
27 defining overweight and obesity using the cut-off points proposed by Cole et al.,²⁶
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29 consumption of fruit and vegetables, daily breakfast, number of hours each day spent
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31 watching television and using computers or game consoles, number of hours each day
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33 spent doing school homework); 2) family variables (employment status of the father,
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35 employment status of the mother, family purchasing power –measured by the Family
36
37 Affluence Scale,²⁷ an index estimated by four items: number of times that the adolescents
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39 have been on holiday with their family in the last 12 months; does the family own a car or
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41 van; does the student have his/her own bedroom; number of computers owned by the
42
43 family-, country of birth of the father, country of birth of the mother, type of household –
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45 both parents, single parent, blended family–, number of minors in the household, number
46
47 of adults in the household); and 3) relationships with the school, the family and friends
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49 (academic achievement, satisfaction with family relationships, satisfaction with
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51 relationships with friends). The variables are categorized in Table 1.
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57 **Data analysis**

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3 The questionnaires with missing values were excluded from data analysis, so that the
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5 number of subjects studied was 17,467 for self-rated health; 17,358 for satisfaction with
6
7 life; 16,803 for health complaints; and 16,560 for health-related quality of life. The
8
9 sample excluding missing values was similar to the original, comparing the main
10
11 socioeconomic variables, health status, and the frequency of undertaking MVPA.
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13
14 The complex sampling design was taken into account during analysis by using the
15
16 “Survey Data” module of the statistical package Stata v11. Standard errors were
17
18 computed by using the linearized variance estimator based on a first-order Taylor series.
19
20 Prevalence was calculated for optimal self-rated health, low level of health complaints,
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22 high satisfaction with life, and the means for the scores on the scale for health-related
23
24 quality of life, with 95% confidence intervals, both global and for the categories of each
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26 one of the exposure variables.
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30 Regression models were used, logistic ones for the estimation of the odds ratio of
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32 prevalence (OR) and linear ones for the calculation of the regression coefficients,
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34 adjusting for the potential confounding variables mentioned above. All co-variables were
35
36 added simultaneously into the models. First, we calculated the association between the
37
38 frequency of undertaking MVPA and health status by estimating OR for the following
39
40 categories: 1-2 days, 3-4 days, 5-6 days, and 7 days, using ‘never’ as the reference.
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42 Second, linear and quadratic trends of the association between MVPA and the health
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44 indicators were calculated from the regression models. For the linear trend, the average
45
46 value for each category was used modelling it as a continuous variable, while for the
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48 quadratic trend the square of these values was used. Statistical significance was set at
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50 $p < 0.05$.
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55 To further explore the relationships between MVPA and health status indicators without
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57 imposing any particular functional form for the dose-response trends, the amount of
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3 moderate-to-vigorous physical activity was entered in regression models using restricted
4 quadratic splines with knots at 1, 3.5, and 6 days/week.²⁸ Restricted quadratic splines
5 allow for different quadratic trends within each intermediate category and linear trends in
6 boundary categories, and hence they can accommodate a wide variety of smooth dose-
7 response curves, while avoiding implausible shapes at the tails of the exposure
8 distribution.

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16 Interactions between MVPA, age and sex were evaluated. Given that interactions were
17 found in the relationship between the frequency of MVPA and health status according to
18 sex, the results are shown separately for males and females.

25 26 **RESULTS**

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29 Table 1 describes the health status of the questionnaire respondents, as estimated by the
30 four health indicators. A total of 91.1% (CI 95%: 90.3-92.0) declared they had an
31 optimal self-rated health, 67.4% (CI 95%: 66.1-68.5) had a low level of health
32 complaints and 90.9% (CI 95%: 90.1-91.6) reported a high satisfaction with life. The
33 mean score on the scale for health-related quality of life was 47.1 (CI 95%: 46.5- 47.6).

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40 According to all the indicators used, the level of health was better, in a statistically
41 significant way, for the questionnaire respondents who indicated that they undertook
42 MVPA more frequently, with gradual increases depending on the categories of MVPA
43 (Table 1). The rest of potentially confounding variables considered, were also associated
44 with self-rated health, less health complaints, high satisfaction with life and health-
45 related quality of life (Tables 1 and 2).

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3 No statistically significant interactions were found between MVPA and age, whereas
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5 statistical significance was reached between MVPA and sex for the indicators self-rated
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7 health and satisfaction with life.
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10 Tables 3 and 4 and Figure 1 show the results of the multivariate analysis that evaluated, for
11
12 each sex separately, the association of the frequency of undertaking MVPA with the
13
14 different indicators of health status, controlling the effect on this association of personal and
15
16 family factors. For both boys and girls, there was a positive, graded and statistically
17
18 significant association (linear trend, $p < 0.001$) between MVPA and self-rated health (Table
19
20 3), with odds ratios (OR) that ranged in males from 2.37, for those who undertook MVPA
21
22 on 1-2 days, to 4.60 and 4.05, for those undertaking it on 5-6 and 7 days, respectively.
23
24 Moving from less than 5 days to 5-6 days of MVPA, the OR increased from 2.34 to 4.60. In
25
26 females, although a positive association was also found, the magnitude of the benefits on
27
28 self-reported health was lower, with values that were half those for the males (OR= 2.14, if
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30 MPVA undertaken 7 days).
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35 Regarding less health complaints (Table 3), an increase in the positive effects was seen in
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37 males from small amounts of MVPA on 1-2 days (OR=1.66, $p=0.008$), which increased
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39 further to an OR of nearly 2 for MVPA on 5-6 days. In females, this effect was lower,
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41 reaching statistical significance after MVPA on 5-6 days with an OR of 1.46 ($p=0.009$). The
42
43 linear trend p-value was statistically significant ($p < 0.001$) in both males and females.
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46 The degree of satisfaction with life (Table 3) was also shown to be significantly associated
47
48 with the frequency of undertaking MVPA; among the boys the OR for high satisfaction
49
50 increased to 1.99 if physical activity was undertaken on 1-2 days per week, and satisfaction
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52 remained at these values for frequencies of more than 5 days of MVPA. In girls, the
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54 magnitude of the effect was similar, but the gradient was steeper. The linear trend p-value
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56 was statistically significant for females ($p < 0.001$), but not for males.
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3 Table 4 shows the same analysis applied to health-related quality of life, considering it
4 as a continuous variable and using linear regression to analyse it. In males, an increasing
5 dose-response effect was seen, especially noticeable after 5-days per week of MVPA
6 ($\beta=3.03$), which increased even further, to 5.08, for those undertaking MVPA for 7-days
7 per week. In females, the benefits were lower at low levels of frequency of MVPA, but
8 reached the same magnitude from 5 days of MVPA. Overall, this indicator was the one
9 that showed fewer differences between boys and girls, as can be seen in Figure 1. The
10 quadratic trend p-value was statistically significant in males ($p=0.006$) and females
11 ($p<0.001$).

22 23 24 25 26 **DISCUSSION**

27 28 **Principal findings**

29
30 The results of this study clearly show the benefits of undertaking physical activity on the
31 health status of adolescents enrolled in schools in Spain. The following results should be
32 highlighted: 1) the magnitude of the effect, with benefits for optimal health reaching OR
33 higher than 4 for males who undertook MVPA daily or on most days, as compared to
34 those who never undertook it; 2) the existence of a dose-response effect, with the
35 positive effects increasing in accordance with the increase in the frequency of MVPA; 3)
36 the consistency of the results with the association present for the four health indicators in
37 both sexes; and 4) the greater positive effect in males, especially at low levels of
38 frequency of MVPA.

39
40 Few studies have linked the effect of MPVA on general indicators of health status in
41 adolescents. Using data from the HBSC study for adolescents from North America,
42 Western Europe, Eastern Europe, Northern Europe and Southern Europe, Iannotti et al.²⁹
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3 evaluated the relationship between the frequency of PA and self-rated health, health
4 complaints and satisfaction with life and found, as in our study, beneficial effects for all
5 three indicators.
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10 **Dose-response relationship**

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12 The dose-response relationship between PA and health implies that increases in PA are
13 related with additional improvements in health status, even when it is not undertaken
14 very frequently. This has also been found in other studies regarding dyslipidemia, blood
15 pressure, overweight and obesity, metabolic syndrome and mental health.^{4,30-32} However,
16 to our knowledge, there are no comparable studies that measure the nature of the
17 relationship on general indicators of health status. Indeed, there is a controversy about
18 whether this relationship is linear or curvilinear, as some studies have found linear
19 patterns, whereas others have not,^{4,30-32} probably because the patterns can be different
20 depending upon the health effect that is being assessed. In our study, a curvilinear
21 relationship was found with a slight slowdown in the health benefits beyond 3-4 days of
22 MVPA in the following indicators: self-rated health; health complaints; and satisfaction
23 with life. In contrast, for health-related quality of life in both sexes, the benefits
24 increased from these intermediate levels of MVPA. These differences in the dose-
25 response relationship suggest that the effect varies depending upon the different
26 dimensions of health status to which the indicators are related. Although self-rated
27 health has been proposed as a measurement of the summary effect of multiple
28 dimensions of health, it is more closely related to the physical dimension rather than the
29 mental and social ones.³³ Similarly, the scale for health complaints is related to
30 symptoms with psychosomatic components very frequently associated with
31 adolescence.³⁴ Yet, the scale for the quality of life, besides including such physical and
32 mental dimensions, also incorporates family and social relationships, which could
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3 suggest that these additional dimensions may be involved in the achieving of greater
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5 health benefits with the maximum frequencies of MVPA.
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8 It should be stressed that the benefits to health status are obtained from low levels of
9
10 MVPA, especially for boys. Similar results have been reported for self-rated health in a
11
12 young adult population³⁵ and regarding blood pressure and dyslipidemia in
13
14 adolescents.^{31,32} This could have important implications for the preventive
15
16 recommendations, because (although 60 minutes of physical activity is currently
17
18 recommended, if possible on a daily basis) the fact that positive results of a moderate
19
20 magnitude can be achieved with very small amounts of MVPA may encourage the
21
22 participation of the more sedentary people. Nevertheless, the maximum benefits were
23
24 obtained according to public health recommendations, so the message should be: “even a
25
26 little is good; more is better”.³⁶
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30 **Gender differences**

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33 The results in health that are derived from undertaking MVPA are greater in males,
34
35 especially in self-rated health and, to a lesser extent, in having less health complaints.
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37 According to our study, females need to undertake more days of MVPA to obtain
38
39 similar health benefits. However, the effect on satisfaction with life and health-related
40
41 quality of life was fairly similar in males and females. These differences suggest that the
42
43 variation of the effect of MVPA according to sex could also be associated to different
44
45 dimensions of health status. Previous reviews have clearly shown important differences
46
47 between males and females in the quantity, intensity and type of physical activity, and
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49 that, in part, these distinctions could be explained by biological differences and those
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51 relating to sociocultural environment and body image.^{21,37} It would, therefore, be
52
53 interesting for subsequent studies to undertake detailed research about this relationship.
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58 **Strengths and weaknesses**

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3 To aid correct interpretation of these data, several limitations should be mentioned. First,
4
5 the limitation in causal inference, stemming from the cross-sectional nature of the study,
6
7 would theoretically affect the temporality of the association. That is, people who have
8
9 health problems can have limitations in undertaking physical exercise. However, from
10
11 the data of the National Health Survey of 2006,³⁸ only 1.7% of adolescents between 16
12
13 and 19 years do not undertake the leisure time physical exercise that they would like to
14
15 take because of health problems, hence, this figure would not affect the results obtained.
16
17 Second, the measurement of health status, MVPA and several covariables of the study is
18
19 based on self-reported information. Although it is difficult to anticipate the magnitude
20
21 and direction of the bias induced by measurement error in self-reported physical activity
22
23 without validity or reproducibility substudies, some degree of attenuation in the
24
25 underlying trends would be expected if the misclassification of physical activity status
26
27 was nondifferential with respect to health outcomes. Nevertheless, the measurement of
28
29 health status using subjective health scales, as in this present study, has been validated in
30
31 previous studies,^{20,23,24,39,40} and such scales are considered to be useful tools especially in
32
33 the stage of adolescence, when psychological aspects are so important in the feeling of
34
35 well-being among young people. The variable used for estimating MVPA has been
36
37 previously validated in an adolescent population of Spain, obtaining an acceptable level
38
39 of validity when compared with measurement using accelerometers.²⁵ Other variables,
40
41 such as self-reported BMI or tobacco consumption, have also been validated in Spain, by
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43 comparing them with objective measurements.^{41,42} Third, it has not been possible to
44
45 differentiate the effect of the intensity of physical activity, which is a dimension
46
47 independently related with self-rated health.³⁵

48
49 The main strengths of this study are the representativeness and large size of the sample
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51 used, which means that the results can be extrapolated accurately, and that the
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3 methodology employed is the standard one for the HBSC study. This is a collaborative
4
5 WHO study in which more than 40 Western countries (including Spain) have
6
7 participated.
8

9 10 **CONCLUSIONS**

11
12 To sum up, an association was found between the frequency of undertaking self-reported
13
14 MVPA and the health status of adolescents enrolled in schools in Spain. A linear trend
15
16 was found for self-rated health, health complaints and for satisfaction with life. For
17
18 health-related quality of life the relationship was quadratic. The benefits of MVPA on
19
20 health were detected from very low levels, below those established by current
21
22 recommendations. In general, the magnitude of association was lower in females than in
23
24 males, a finding that needs to be explained by subsequent research.
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32
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34
35

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37
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39
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41
42 interpretation of data and revision of the manuscript. All authors approved the final
43
44 version.
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46
47

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49
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51
52 of Health and Social Policy].
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54

55 **Competing interests:** None.
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3 **Ethics approval:** This study was approved by the Institutional Review Board of the
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5 Carlos III Institute of Health.
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8 **Provenance and peer review:** Not commissioned; externally peer reviewed.
9

10 **Data sharing statement:** Full results of the Spanish HBSC study are available at
11
12 <http://www.msps.es/profesionales/saludPublica/prevPromocion/promocion/saludJovenes>
13
14 [/estudioHBSC/nacional_hbsc.htm](http://www.msps.es/profesionales/saludPublica/prevPromocion/promocion/saludJovenes)
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Table 1. Description of the sample and distribution of optimal self-rated health, less health complaints, high satisfaction with life and health-related quality of life, according to individual variables. Spanish adolescents aged 11–18 years, 2006.

		Optimal Self-reported health N (17467)	Less health complaints N (16803)	High satisfaction with life N (17358)	Health-related quality of life N (16560)
		%	%	%	Mean
MVPA	Global	91.1	67.4	90.9	47.1
	Never	80.1*	54.1*	82.3*	42.6*
	1-2 days	87.5	62.8	87.4	44.3
	3-4 days	90.8	66.3	91.3	46.2
	5-6 days	94.8	72.8	93.1	48.2
Sex	7 days	95.9	74.1	95.2	52.5
	Men	93.3*	76.7*	91.9*	48.3*
Age	Women	89.3	59.5	90.0	46.1
	10-12	95.8*	68.6	94.9*	52.5*
	13-16	90.1	67.6	89.8	45.6
Born in Spain	17-18	86.8	65.1	87.7	43.2
	Yes	91.1	67.7*	91.2*	47.2
	No	91.2	62.9	85.3	45.7
Smoking	Non-smoker	94.5*	70.6*	94.0*	49.3*
	Smoker	80.9	56.6	83.7	42.8
	Ex-smoker	89.2	66.6	86.9	44.1
Consumption of alcohol	Never	95.4*	70.4*	94.3*	50.7*
	Rarely	89.9	65.2	88.9	45.4
	Monthly	88.1	66.3	87.2	43.5
	Weekly or daily	85.2	64.2	87.9	43.9
Body-mass index	Normal or underweight	92.5*	68.2*	91.5*	47.0
	Overweight	86.7	67.6	90.3	47.1
	Obese	77.4	58.0	83.0	46.6
	NR	90.4	64.6	89.4	47.2
Consumption of fruit and vegetables	Quartile 1	88.2*	64.1*	88.8*	45.8*
	Quartile 2	91.5	67.5	91.5	46.5
	Quartile 3	92.5	69.7	92.2	47.2
	Quartile 4	92.6	68.5	91.2	48.7
Breakfast during the week	Every day	93.2*	70.4*	92.6*	48.1*
	Not every day	85.5	59.1	86.1	44.3
Time spent TV and computers	Quartile 1	91.1	68.7*	91.5*	48.0*
	Quartile 2	91.1	69.4	91.8	47.0
	Quartile 3	91.7	68.8	91.5	47.0
	Quartile 4	90.2	62.8	88.7	46.2
	NR	92.6	65.4	89.3	48.6
Time spent studying/ homework	Quartile 1	89.3*	68.8*	87.1*	46.3*
	Quartile 2	92.2	69.3	91.9	47.9
	Quartile 3	92.4	68.8	92.5	47.7
	Quartile 4	90.5	62.9	91.5	46.3
	NR	89.4	69.3	88.6	48.4
Academic achievement	Very good	96.3*	71.8*	96.4*	52.4*
	Good	94.0	69.7	94.2	48.2
	Average	87.4	65.3	87.3	44.2
	Low	79.7	54.0	75.3	41.7

* $p < 0.05$

MVPA: Moderate-to-Vigorous Physical Activity

NR: Non-response

Table 2. Description of the sample and distribution of optimal self-rated health, less health complaints, high satisfaction with life and health-related quality of life, according to family variables. Spanish adolescents aged 11–18 years, 2006.

	Optimal Self-reported health N (17467)	Less health complaints N (16803)	High satisfaction with life N (17358)	Health-related quality of life N (16560)
	%	%	%	Mean
Employment situation of father				
Paid employment	91.5*	67.8*	91.3*	47.2*
No paid employment	86.9	63.0	85.4	45.4
Don't know	90.3	52.9	91.5	43.3
No father	85.4	59.8	82.0	44.3
Employment situation of mother				
Paid employment	91.0	67.1	90.8*	47.1*
No paid employment	91.5	68.3	91.4	47.0
Don't know	90.9	59.1	91.4	47.5
No mother	83.7	58.7	78.0	45.2
Socioeconomic status				
Low	86.2*	62.6*	84.5*	45.2*
Average	91.2	66.7	90.9	46.9
High	92.9	69.9	93.2	48.0
Country of birth of father				
Spain	91.1	67.6	91.2*	47.1
Other countries	91.1	64.7	86.2	46.4
Country of birth of mother				
Spain	91.1	67.7*	91.1*	47.1
Other countries	91.9	62.4	87.3	46.1
Type of household				
Both parents	92.0*	68.4*	91.9*	47.3*
Single parent	86.9	62.2	85.0	45.7
Blended	83.0	59.3	82.6	44.2
Others	85.3	61.3	86.8	46.8
Number of adults in the household				
2	91.7*	64.1*	91.2*	47.3
0,1,3,4,5	88.8	68.3	89.3	46.4
Number of minors in the household				
1,2,3	91.1	60.3*	91.0	47.1
>3	90.6	68.0	88.8	46.8
Satisfaction: family relationships ^a				
Good	93.0*	45.2*	94.2*	48.0*
Fair-bad	75.9	70.1	64.2	39.4
Satisfaction: relationships with friends ^a				
Good	92.0*	48.5*	92.3*	47.5*
Fair-bad	77.1	68.6	68.5	40.0

* $p < 0.05$

^a Good: score 7-10; Fair-bad: score 0-6

Table 3. Logistic models. Association between the amount of moderate-to-vigorous physical activity and optimal self-rated health, less health complaints and high satisfaction with life. Spanish adolescents aged 11–18 years, 2006.

	Men		Women		
	OR* (95% CI)	P	OR* (95% CI)	P	
Optimal self-rated health					
Frequency of undertaking MVPA					
Never	1 (ref)		1 (ref)		
1-2 days	2.37 (1.56 to 3.58)	<0.001	1.20 (0.85 to 1.69)	0.282	
3-4 days	2.34 (1.44 to 3.81)	0.001	1.51 (1.06 to 2.14)	0.020	
5-6 days	4.60 (2.60 to 8.13)	<0.001	2.28 (1.47 to 3.52)	<0.001	
7 days	4.05 (2.38 to 6.89)	<0.001	2.14 (1.37 to 3.34)	0.001	
Linear trend P-value	<0.001		<0.001		
Quadratic trend P-value	0.325		0.850		
Less health complaints					
Frequency of undertaking MVPA					
Never	1 (ref)		1 (ref)		
1-2 days	1.66 (1.14 to 2.42)	0.008	1.16 (0.90 to 1.49)	0.226	
3-4 days	1.65 (1.14 to 2.39)	0.007	1.21 (0.93 to 1.58)	0.143	
5-6 days	2.09 (1.47 to 2.96)	<0.001	1.46 (1.10 to 1.93)	0.009	
7 days	1.94 (1.38 to 2.73)	<0.001	1.32 (0.97 to 1.80)	0.076	
Linear trend P-value	0.001		0.021		
Quadratic trend P-value	0.216		0.463		
High satisfaction with life					
Frequency of undertaking MVPA					
Never	1 (ref)		1 (ref)		
1-2 days	1.99 (1.20 to 3.31)	0.007	0.93 (0.63 to 1.36)	0.722	
3-4 days	1.52 (0.90 to 2.55)	0.111	1.44 (0.99 to 2.10)	0.056	
5-6 days	2.02 (1.17 to 3.49)	0.011	1.56 (0.98 to 2.49)	0.059	
7 days	1.94 (1.09 to 3.44)	0.023	2.00 (1.19 to 3.35)	0.008	
Linear trend P-value	0.128		<0.001		
Quadratic trend P-value	0.661		0.975		

* Adjusted for age, country of birth, smoking, alcohol consumption, BMI, consumption of fruit and vegetables, daily breakfast, time spent watching TV using computers, time spent studying, academic achievement, employment situation of the father and mother, socioeconomic status, country of birth of the father and mother, type of household, number of adults and number of minors in the household, satisfaction with family relationships and with friends.

Table 4. Linear models. Association between the amount of moderate-to-vigorous physical activity and health-related quality of life. Spanish adolescents aged 11–18 years, 2006.

	Men		Women	
	β * (95% CI)	P	β * (95% CI)	P
Frequency of undertaking MVPA				
Never	0 (ref)		0 (ref)	
1-2 days	1.61 (0.29 to 2.93)	0.017	0.19 (- 0.71 to 1.10)	0.676
3-4 days	1.87 (0.50 to 3.24)	0.007	1.19 (0.37 to 2.02)	0.005
5-6 days	3.03 (1.74 to 4.31)	<0.001	2.79 (1.76 to 3.82)	<0.001
7 days	5.08 (3.73 to 6.43)	<0.001	5.09 (3.86 to 6.32)	<0.001
Linear trend P-value	<0.001		<0.001	
Quadratic trend P-value	0.006		<0.001	

* Adjusted for age, country of birth, smoking, alcohol consumption, BMI, consumption of fruit and vegetables, daily breakfast, time spent watching TV and using computers, time spent studying, academic achievement, employment situation of the father and mother, socioeconomic status, country of birth of the father and mother, type of household, number of adults and number of minors in the household, satisfaction with family relationships and with friends.

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3 Figure 1. Dose-response relationship of the amount of self-reported Moderate-to-
4 Vigorous Physical Activity (MVPA) with optimal self-rated health, less health
5 complaints, high satisfaction with life, and health-related quality of life among Spanish
6 adolescents aged 11–18 years.
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11 *Footnote:*

12 Curves represent adjusted odds ratios or mean differences (solid lines) and their 95%
13 confidence intervals (dashed lines) based on restricted quadratic splines for the amount
14 of MVPA with knots at 1, 3.5, and 6 days/week. The reference value (odds ratio = 1 and
15 mean difference = 0) was set at 0 days/week of moderate-vigorous physical activity.
16 Odds ratios and mean differences were obtained from logistic and linear regression
17 models accounting for the complex survey and adjusted for personal and familial risk
18 factors (see Methods). Bars represent the weighted bar charts of the amount of MVPA
19 among men and women.
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3 **Physical activity and self-reported health status among adolescents: a cross-sectional**
4 **population-based study**
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Abstract

Objectives: Little is known about the dose-response relationship between physical activity and health benefits among young people. Our objective was to analyse the association between the frequency of undertaking Moderate-to-Vigorous Physical Activity (MVPA) and the self-reported health status of the adolescent population.

Design: Cross-sectional study.

Setting: All regions of Spain.

Participants: Students aged 11-18 years participating in the Spanish Health Behaviour in School-aged Children (HBSC) survey 2006. A total of 375 schools and 21,188 students were selected.

Main outcomes: The frequency of undertaking MVPA was measured by questionnaire, as were the following four health indicators: self-rated health, health complaints, satisfaction with life, and health-related quality of life. Linear and logistic regression models were used to analyse the association, adjusting for potential confounding variables and the modelling of the dose-response relationship.

Results: As the frequency of MVPA increased, the association with health benefits was stronger. A linear trend ($p < 0.05$) was found for self-rated health and health complaints in males and females, and for satisfaction with life among females; for health-related quality of life, this relationship was quadratic for both sexes ($p < 0.05$). For self-reported health and health complaints, the effect was found to be of greater magnitude in males than in females and, in all scales, the benefits were observed from the lowest frequencies of MVPA, especially in males.

Conclusions: A protective effect of MVPA was found in both sexes for the four health indicators studied, and this activity had a gradient effect. Among males, health benefits

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3 were detected from very low levels of physical activity and the magnitude of the
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5 relationship was greater than that for females.
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For peer review only

Article summary

Article focus

- Although it is recommended that all adolescents should undertake 60 minutes of daily Moderate-to-Vigorous Physical Activity (MVPA), little is known about the nature of the relationship in this population, and whether or not the effect varies depending on age and sex.
- We examined cross-sectional associations between the frequency of undertaking self-reported MVPA and the health status of the adolescent population, using subjective health scales that are considered to be useful tools especially in the stage of adolescence, when psychological aspects are so important in the feeling of well-being among young people.

Key messages

- The protective effect of MVPA on health was detected from very low levels, below those established by current recommendations.
- A linear trend was found for self-rated health, health complaints and for satisfaction with life. For health-related quality of life the relationship was quadratic.
- The positive effect on health produced lower results in females than in males.

Strengths and limitations of this study

- The main strength is the representativeness and large size of the sample. The methodology employed is the standard one for the HBSC study in which more than 40 Western countries have participated.
- A major limitation is the cross-sectional nature of the study. Moreover, the measurement of health status using subjective health scales and the estimation of MVPA are both based on self-reported information.

INTRODUCTION

According to the World Health Organization (WHO)¹, physical inactivity is the fourth most important risk factor affecting global mortality, to which nearly 6% of all deaths are attributed. In the adolescent population, short-term benefits related to Physical Activity (PA) are improvements in lipid profile, blood pressure, metabolic syndrome, muscular strength and bone density, together with a reduction in obesity and overweight levels, as well as a decrease in emotional problems and depressive symptoms.²⁻⁵ Moreover, young people who undertake PA adopt healthy behaviour more easily and have better levels of academic achievement and cognitive functioning.^{4, 6-8}

The dose-response relationship between physical activity and various health indicators has mainly been studied in the adult population,⁹⁻¹⁵ where there is still a controversy about whether or not this relationship is linear.^{12,16} Ekelund et al.,¹⁷ in a pooled data analysis of 14 studies in children and adolescents, found a direct benefit between three tertiles of Moderate-to-Vigorous Physical Activity (MVPA) in relation to cardiometabolic outcomes. Although the WHO recommends that all children of 5-17 years of age take at least 60 minutes of daily MVPA,¹⁸ little is known about the nature of the relationship in this population. Therefore, finding out the effect on health of several levels of PA could have important implications for improving the recommendations regarding this activity.

It should be emphasized that concepts underlying health status in children and adolescents differ from those for adults. As young people are still developing, the measurement of health status must be approached from a global and comprehensive perspective for each individual. Concepts such as 'subjective health' and 'health-related quality of life' cover complex physical, emotional, mental and social aspects.^{19,20} Hence,

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3 it is important to evaluate if the effect of the PA is distributed in a distinct way for the
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5 different dimensions of health status.
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8 Finally, although PA varies considerably depending on age and sex,²¹ to our knowledge
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10 there have been very few studies in the literature about the role that these variables play
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12 regarding the effect of PA on health.⁴
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15 The objective of this study was to analyse the association between the frequency of
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17 undertaking MVPA and the different dimensions of adolescent health status, assessing if
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19 this relationship differs according to age and sex.
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22 23 24 25 **METHODS**

26 27 **Study population**

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30 The source of information was the Health Behaviour in School-aged Children (HBSC)
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32 study carried out in 2006.²² The population was a representative sample of
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34 preadolescents and adolescents, with an age range of 11-18 years, resident in Spain and
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36 enrolled in school from the 5th year of primary school to the last year of upper
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38 secondary school (2nd year of baccalaureate). A multistage stratified random sampling
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40 was used, taking into account age strata (4 groups), region (17 autonomous
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42 communities), school site (rural and urban), and type of school (public and private).
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44 Initially, 480 schools were contacted of which 377 (103 private and 274 public schools)
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46 agreed to participate in the study, which represented a response rate of 78.5%. **On**
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48 **average, three classes were selected in each school.** A total of 22,350 questionnaires
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50 were collected, although subsequently 539 were excluded because of non-response to
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52 questions about sex and age, or lack of response to more than 50% of the questionnaire.
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57 The sample size was 21,811 participants. The study was carried out in spring 2006.
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3 Previously trained survey technicians visited the selected schools, where the students
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5 completed an anonymous questionnaire during normal school hours.
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8 This study was approved by the Institutional Review Board of the Carlos III Institute of
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10 Health .
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12 Study variables

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14 Health status was measured using four indicators: 1) self-rated health was measured using
15 the question “*Would you say that your health is: excellent, good, fair or bad*”. Optimal
16 health status was categorized by a response of excellent or good, and sub-optimal health
17 status was categorized by a response of fair or bad. 2) The health complaints indicator
18 was assessed using a scale based on the HBSC-Symptom Checklist, which is a list of
19 eight physical and psychological symptoms (headaches, abdominal pain, backache,
20 feeling low, irritability, nervousness, sleeping difficulties and dizziness), to estimate their
21 frequency during the last six months. Having 2 or more symptoms with a frequency of
22 several times a week or daily was considered to define having noticeable subjective
23 health complaints.¹⁹ 3) Satisfaction with life was estimated using the Cantril Ladder,²³ in
24 which, using a scale from 0 to 10, the participant was asked “*on which rung of the ladder*
25 *(scale from 0 to 10) do you feel you stand at this moment in your life?*”, with 0 being the
26 worst score and 10 the best. A score of 0 to 5 was categorized as dissatisfied, whereas a
27 score of 6 to 10 was categorized as satisfied.¹⁹ 4) Health-related quality of life was
28 measured using the Kidscreen-10 index,²⁴ a series of 10 questions about mood, ability to
29 concentrate, energy, vitality, well-being, ability to have fun with friends. Each question
30 has five categories of response ranging from “never” to “always” or from “not at all” to
31 “extremely often”. The items fulfil the assumptions of the Rasch model. To make the
32 interpretation more applicable, the scores of the Rasch scales are translated into T-values
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3 with scale means of 50 and standard deviation of 10, with higher values indicating higher
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5 health-related quality of life.²⁴
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8 The frequency of MVPA was measured using the question: “*in the last seven days,*
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10 *considering moderate and vigorous activity... On how many days did you feel you were*
11 *physically active for a total of 60 minutes per day?*” The response categories were from 0
12 to 7 days. This question, when compared with PA assessed by accelerometers in Spanish
13 adolescents, has shown an acceptable validation.²⁵
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20 The following factors were considered as potentially confounding variables for the
21 association between health status and frequency of MVPA: 1) personal variables (sex,
22 age, country of birth, current smoker, alcohol consumption, body-mass index –calculated
23 as the ratio of weight in kg/height in m² from self-reported weight and height, and
24 defining overweight and obesity using the cut-off points proposed by Cole et al.,²⁶
25 consumption of fruit and vegetables, daily breakfast, number of hours each day spent
26 watching television and using computers or game consoles, number of hours each day
27 spent doing school homework); 2) family variables (employment status of the father,
28 employment status of the mother, family purchasing power –measured by the Family
29 Affluence Scale,²⁷ an index estimated by four items: number of times that the adolescents
30 have been on holiday with their family in the last 12 months; does the family own a car or
31 van; does the student have his/her own bedroom; number of computers owned by the
32 family-, country of birth of the father, country of birth of the mother, type of household –
33 both parents, single parent, blended family–, number of minors in the household, number
34 of adults in the household); and 3) relationships with the school, the family and friends
35 (academic achievement, satisfaction with family relationships, satisfaction with
36 relationships with friends). The variables are categorized in Table 1.
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57 **Data analysis**

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3 The questionnaires with missing values were excluded from data analysis, so that the
4
5 number of subjects studied was 17,467 for self-rated health; 17,358 for satisfaction with
6
7 life; 16,803 for health complaints; and 16,560 for health-related quality of life. The
8
9 sample excluding missing values was similar to the original, comparing the main
10
11 socioeconomic variables, health status, and the frequency of undertaking MVPA.
12

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14 The complex sampling design was taken into account during analysis by using the
15
16 “Survey Data” module of the statistical package Stata v11. Standard errors were
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18 computed by using the linearized variance estimator based on a first-order Taylor series.
19
20 Prevalence was calculated for optimal self-rated health, low level of health complaints,
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22 high satisfaction with life, and the means for the scores on the scale for health-related
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24 quality of life, with 95% confidence intervals, both global and for the categories of each
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26 one of the exposure variables.
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30 Regression models were used, logistic ones for the estimation of the odds ratio of
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32 prevalence (OR) and linear ones for the calculation of the regression coefficients,
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34 adjusting for the potential confounding variables mentioned above. All co-variables were
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36 added simultaneously into the models. First, we calculated the association between the
37
38 frequency of undertaking MVPA and health status by estimating OR for the following
39
40 categories: 1-2 days, 3-4 days, 5-6 days, and 7 days, using ‘never’ as the reference.
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42 Second, linear and quadratic trends of the association between MVPA and the health
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44 indicators were calculated from the regression models. For the linear trend, the average
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46 value for each category was used modelling it as a continuous variable, while for the
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48 quadratic trend the square of these values was used. Statistical significance was set at
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50 $p < 0.05$.
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55 To further explore the relationships between MVPA and health status indicators without
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57 imposing any particular functional form for the dose-response trends, the amount of
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3 moderate-to-vigorous physical activity was entered in regression models using restricted
4 quadratic splines with knots at 1, 3.5, and 6 days/week.²⁸ Restricted quadratic splines
5 allow for different quadratic trends within each intermediate category and linear trends in
6 boundary categories, and hence they can accommodate a wide variety of smooth dose-
7 response curves, while avoiding implausible shapes at the tails of the exposure
8 distribution.

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16 Interactions between MVPA, age and sex were evaluated. Given that interactions were
17 found in the relationship between the frequency of MVPA and health status according to
18 sex, the results are shown separately for males and females.

25 26 RESULTS

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29 Table 1 describes the health status of the questionnaire respondents, as estimated by the
30 four health indicators. A total of 91.1% (CI 95%: 90.3-92.0) declared they had an
31 optimal self-rated health, 67.4% (CI 95%: 66.1-68.5) had a low level of health
32 complaints and 90.9% (CI 95%: 90.1-91.6) reported a high satisfaction with life. The
33 mean score on the scale for health-related quality of life was 47.1 (CI 95%: 46.5- 47.6).

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40 According to all the indicators used, the level of health was better, in a statistically
41 significant way, for the questionnaire respondents who indicated that they undertook
42 MVPA more frequently, with gradual increases depending on the categories of MVPA
43 (Table 1). **The rest of potentially confounding variables considered, were also associated**
44 **with self-rated health, less health complaints, high satisfaction with life and health-**
45 **related quality of life (Tables 1 and 2).**

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3 No statistically significant interactions were found between MVPA and age, whereas
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5 statistical significance was reached between MVPA and sex for the indicators self-rated
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7 health and satisfaction with life.
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10 Tables 3 and 4 and Figure 1 show the results of the multivariate analysis that evaluated, for
11
12 each sex separately, the association of the frequency of undertaking MVPA with the
13
14 different indicators of health status, controlling the effect on this association of personal and
15
16 family factors. For both boys and girls, there was a positive, graded and statistically
17
18 significant association (linear trend, $p < 0.001$) between MVPA and self-rated health (Table
19
20 3), with odds ratios (OR) that ranged in males from 2.37, for those who undertook MVPA
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22 on 1-2 days, to 4.60 and 4.05, for those undertaking it on 5-6 and 7 days, respectively.
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24 Moving from less than 5 days to 5-6 days of MVPA, the OR increased from 2.34 to 4.60. In
25
26 females, although a positive association was also found, the magnitude of the benefits on
27
28 self-reported health was lower, with values that were half those for the males (OR= 2.14, if
29
30 MPVA undertaken 7 days).
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35 Regarding less health complaints (Table 3), an increase in the positive effects was seen in
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37 males from small amounts of MVPA on 1-2 days (OR=1.66, $p=0.008$), which increased
38
39 further to an OR of nearly 2 for MVPA on 5-6 days. In females, this effect was lower,
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41 reaching statistical significance after MVPA on 5-6 days with an OR of 1.46 ($p=0.009$). The
42
43 linear trend p-value was statistically significant ($p < 0.001$) in both males and females.
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46 The degree of satisfaction with life (Table 3) was also shown to be significantly associated
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48 with the frequency of undertaking MVPA; among the boys the OR for high satisfaction
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50 increased to 1.99 if physical activity was undertaken on 1-2 days per week, and satisfaction
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52 remained at these values for frequencies of more than 5 days of MVPA. In girls, the
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54 magnitude of the effect was similar, but the gradient was steeper. The linear trend p-value
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56 was statistically significant for females ($p < 0.001$), but not for males.
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3 Table 4 shows the same analysis applied to health-related quality of life, considering it
4 as a continuous variable and using linear regression to analyse it. In males, an increasing
5 dose-response effect was seen, especially noticeable after 5-days per week of MVPA
6 ($\beta=3.03$), which increased even further, to 5.08, for those undertaking MVPA for 7-days
7 per week. In females, the benefits were lower at low levels of frequency of MVPA, but
8 reached the same magnitude from 5 days of MVPA. Overall, this indicator was the one
9 that showed fewer differences between boys and girls, as can be seen in Figure 1. The
10 quadratic trend p-value was statistically significant in males ($p=0.006$) and females
11 ($p<0.001$).

22 23 24 25 26 **DISCUSSION**

27 28 **Principal findings**

29
30 The results of this study clearly show the benefits of undertaking physical activity on the
31 health status of adolescents enrolled in schools in Spain. The following results should be
32 highlighted: 1) the magnitude of the effect, with benefits for optimal health reaching OR
33 higher than 4 for males who undertook MVPA daily or on most days, as compared to
34 those who never undertook it; 2) the existence of a dose-response effect, with the
35 positive effects increasing in accordance with the increase in the frequency of MVPA; 3)
36 the consistency of the results with the association present for the four health indicators in
37 both sexes; and 4) the greater positive effect in males, especially at low levels of
38 frequency of MVPA.

39
40 Few studies have linked the effect of MPVA on general indicators of health status in
41 adolescents. Using data from the HBSC study for adolescents from North America,
42 Western Europe, Eastern Europe, Northern Europe and Southern Europe, Iannotti et al.²⁹
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3 evaluated the relationship between the frequency of PA and self-rated health, health
4 complaints and satisfaction with life and found, as in our study, beneficial effects for all
5 three indicators.
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9 10 **Dose-response relationship**

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12 The dose-response relationship between PA and health implies that increases in PA are
13 related with additional improvements in health status, even when it is not undertaken
14 very frequently. This has also been found in other studies regarding dyslipidemia, blood
15 pressure, overweight and obesity, metabolic syndrome and mental health.^{4,30-32} However,
16 to our knowledge, there are no comparable studies that measure the nature of the
17 relationship on general indicators of health status. Indeed, there is a controversy about
18 whether this relationship is linear or curvilinear, as some studies have found linear
19 patterns, whereas others have not,^{4,30-32} probably because the patterns can be different
20 depending upon the health effect that is being assessed. In our study, a curvilinear
21 relationship was found with a slight slowdown in the health benefits beyond 3-4 days of
22 MVPA in the following indicators: self-rated health; health complaints; and satisfaction
23 with life. In contrast, for health-related quality of life in both sexes, the benefits
24 increased from these intermediate levels of MVPA. These differences in the dose-
25 response relationship suggest that the effect varies depending upon the different
26 dimensions of health status to which the indicators are related. Although self-rated
27 health has been proposed as a measurement of the summary effect of multiple
28 dimensions of health, it is more closely related to the physical dimension rather than the
29 mental and social ones.³³ Similarly, the scale for health complaints is related to
30 symptoms with psychosomatic components very frequently associated with
31 adolescence.³⁴ Yet, the scale for the quality of life, besides including such physical and
32 mental dimensions, also incorporates family and social relationships, which could
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3 suggest that these additional dimensions may be involved in the achieving of greater
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5 health benefits with the maximum frequencies of MVPA.
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8 It should be stressed that the benefits to health status are obtained from low levels of
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10 **MVPA**, especially for boys. Similar results have been reported for self-rated health in a
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12 young adult population³⁵ and regarding blood pressure and dyslipidemia in
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14 adolescents.^{31,32} This could have important implications for the preventive
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16 recommendations, because (although 60 minutes of physical activity is currently
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18 recommended, if possible on a daily basis) the fact that positive results of a moderate
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20 magnitude can be achieved with very small amounts of MVPA **may** encourage the
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22 participation of the more sedentary people. Nevertheless, the maximum benefits were
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24 obtained according to public health recommendations, so the message should be: “even a
25
26 little is good; more is better”.³⁶
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30 **Gender differences**

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33 The results in health that are derived from undertaking MVPA are greater in males,
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35 especially in self-rated health and, to a lesser extent, in having less health complaints.
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37 According to our study, females need to undertake more days of MVPA to obtain
38
39 similar health benefits. However, the effect on satisfaction with life and health-related
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41 quality of life was fairly similar in males and females. These differences suggest that the
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43 variation of the effect of MVPA according to sex could also be associated to different
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45 dimensions of health status. Previous reviews have clearly shown important differences
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47 between males and females in the quantity, intensity and type of physical activity, and
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49 that, in part, these distinctions could be explained by biological differences and those
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51 relating to sociocultural environment and body image.^{21,37} It would, therefore, be
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53 interesting for subsequent studies to undertake detailed research about this relationship.
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58 **Strengths and weaknesses**

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3 To aid correct interpretation of these data, several limitations should be mentioned. First,
4 the limitation in causal inference, stemming from the cross-sectional nature of the study,
5 would theoretically affect the temporality of the association. That is, people who have
6 health problems can have limitations in undertaking physical exercise. However, from
7 the data of the National Health Survey of 2006,³⁸ only 1.7% of adolescents between 16
8 and 19 years do not undertake the leisure time physical exercise that they would like to
9 take because of health problems, hence, this figure would not affect the results obtained.

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Second, the measurement of health status, MVPA and several covariables of the study is based on self-reported information. Although it is difficult to anticipate the magnitude and direction of the bias induced by measurement error in self-reported physical activity without validity or reproducibility substudies, some degree of attenuation in the underlying trends would be expected if the misclassification of physical activity status was nondifferential with respect to health outcomes. Nevertheless, the measurement of health status using subjective health scales, as in this present study, has been validated in previous studies,^{20,23,24,39,40} and such scales are considered to be useful tools especially in the stage of adolescence, when psychological aspects are so important in the feeling of well-being among young people. The variable used for estimating MVPA has been previously validated in an adolescent population of Spain, obtaining an acceptable level of validity when compared with measurement using accelerometers.²⁵ Other variables, such as self-reported BMI or tobacco consumption, have also been validated in Spain, by comparing them with objective measurements.^{41,42} Third, it has not been possible to differentiate the effect of the intensity of physical activity, which is a dimension independently related with self-rated health.³⁵

The main strengths of this study are the representativeness and large size of the sample used, which means that the results can be extrapolated accurately, and that the

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2
3 methodology employed is the standard one for the HBSC study. This is a collaborative
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5 WHO study in which more than 40 Western countries (including Spain) have
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7 participated.
8

9 10 **CONCLUSIONS**

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12 To sum up, an association was found between the frequency of undertaking **self-reported**
13
14 MVPA and the health status of adolescents enrolled in schools in Spain. A linear trend
15
16 was found for self-rated health, health complaints and for satisfaction with life. For
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18 health-related quality of life the relationship was quadratic. The benefits of MVPA on
19
20 health **were** detected from very low levels, below those established by current
21
22 recommendations. In general, **the magnitude of association was lower** in females than in
23
24 males, a finding that needs to be explained by subsequent research.
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32
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34
35

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37
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39
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41
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43
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47

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49
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51
52 of Health and Social Policy].
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54

55 **Competing interests:** None.
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3 **Ethics approval:** This study was approved by the Institutional Review Board of the
4
5 Carlos III Institute of Health.
6

7
8 **Provenance and peer review:** Not commissioned; externally peer reviewed.
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10 **Data sharing statement:** Full results of the Spanish HBSC study are available at
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12 <http://www.msps.es/profesionales/saludPublica/prevPromocion/promocion/saludJovenes>
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14 [/estudioHBSC/nacional_hbsc.htm](http://www.msps.es/profesionales/saludPublica/prevPromocion/promocion/saludJovenes)
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Table 1. Description of the sample and distribution of optimal self-rated health, less health complaints, high satisfaction with life and health-related quality of life, according to individual variables. Spanish adolescents aged 11–18 years, 2006.

		Optimal Self-reported health N (17467)	Less health complaints N (16803)	High satisfaction with life N (17358)	Health-related quality of life N (16560)
		%	%	%	Mean
MVPA	Global	91.1	67.4	90.9	47.1
	Never	80.1*	54.1*	82.3*	42.6*
	1-2 days	87.5	62.8	87.4	44.3
	3-4 days	90.8	66.3	91.3	46.2
	5-6 days	94.8	72.8	93.1	48.2
Sex	7 days	95.9	74.1	95.2	52.5
	Men	93.3*	76.7*	91.9*	48.3*
Age	Women	89.3	59.5	90.0	46.1
	10-12	95.8*	68.6	94.9*	52.5*
	13-16	90.1	67.6	89.8	45.6
Born in Spain	17-18	86.8	65.1	87.7	43.2
	Yes	91.1	67.7*	91.2*	47.2
	No	91.2	62.9	85.3	45.7
Smoking	Non-smoker	94.5*	70.6*	94.0*	49.3*
	Smoker	80.9	56.6	83.7	42.8
	Ex-smoker	89.2	66.6	86.9	44.1
Consumption of alcohol	Never	95.4*	70.4*	94.3*	50.7*
	Rarely	89.9	65.2	88.9	45.4
	Monthly	88.1	66.3	87.2	43.5
	Weekly or daily	85.2	64.2	87.9	43.9
Body-mass index	Normal or underweight	92.5*	68.2*	91.5*	47.0
	Overweight	86.7	67.6	90.3	47.1
	Obese	77.4	58.0	83.0	46.6
	NR	90.4	64.6	89.4	47.2
Consumption of fruit and vegetables	Quartile 1	88.2*	64.1*	88.8*	45.8*
	Quartile 2	91.5	67.5	91.5	46.5
	Quartile 3	92.5	69.7	92.2	47.2
	Quartile 4	92.6	68.5	91.2	48.7
Breakfast during the week	Every day	93.2*	70.4*	92.6*	48.1*
	Not every day	85.5	59.1	86.1	44.3
Time spent TV and computers	Quartile 1	91.1	68.7*	91.5*	48.0*
	Quartile 2	91.1	69.4	91.8	47.0
	Quartile 3	91.7	68.8	91.5	47.0
	Quartile 4	90.2	62.8	88.7	46.2
	NR	92.6	65.4	89.3	48.6
Time spent studying/ homework	Quartile 1	89.3*	68.8*	87.1*	46.3*
	Quartile 2	92.2	69.3	91.9	47.9
	Quartile 3	92.4	68.8	92.5	47.7
	Quartile 4	90.5	62.9	91.5	46.3
	NR	89.4	69.3	88.6	48.4
Academic achievement	Very good	96.3*	71.8*	96.4*	52.4*
	Good	94.0	69.7	94.2	48.2
	Average	87.4	65.3	87.3	44.2
	Low	79.7	54.0	75.3	41.7

* p<0.05

MVPA: Moderate-to-Vigorous Physical Activity

NR: Non-response

Table 2. Description of the sample and distribution of optimal self-rated health, less health complaints, high satisfaction with life and health-related quality of life, according to family variables. Spanish adolescents aged 11–18 years, 2006.

	Optimal Self-reported health N (17467)	Less health complaints N (16803)	High satisfaction with life N (17358)	Health-related quality of life N (16560)
	%	%	%	Mean
Employment situation of father				
Paid employment	91.5*	67.8*	91.3*	47.2*
No paid employment	86.9	63.0	85.4	45.4
Don't know	90.3	52.9	91.5	43.3
No father	85.4	59.8	82.0	44.3
Employment situation of mother				
Paid employment	91.0	67.1	90.8*	47.1*
No paid employment	91.5	68.3	91.4	47.0
Don't know	90.9	59.1	91.4	47.5
No mother	83.7	58.7	78.0	45.2
Socioeconomic status				
Low	86.2*	62.6*	84.5*	45.2*
Average	91.2	66.7	90.9	46.9
High	92.9	69.9	93.2	48.0
Country of birth of father				
Spain	91.1	67.6	91.2*	47.1
Other countries	91.1	64.7	86.2	46.4
Country of birth of mother				
Spain	91.1	67.7*	91.1*	47.1
Other countries	91.9	62.4	87.3	46.1
Type of household				
Both parents	92.0*	68.4*	91.9*	47.3*
Single parent	86.9	62.2	85.0	45.7
Blended	83.0	59.3	82.6	44.2
Others	85.3	61.3	86.8	46.8
Number of adults in the household				
2	91.7*	64.1*	91.2*	47.3
0,1,3,4,5	88.8	68.3	89.3	46.4
Number of minors in the household				
1,2,3	91.1	60.3*	91.0	47.1
>3	90.6	68.0	88.8	46.8
Satisfaction: family relationships ^a				
Good	93.0*	45.2*	94.2*	48.0*
Fair-bad	75.9	70.1	64.2	39.4
Satisfaction: relationships with friends ^a				
Good	92.0*	48.5*	92.3*	47.5*
Fair-bad	77.1	68.6	68.5	40.0

* $p < 0.05$

^a Good: score 7-10; Fair-bad: score 0-6

Table 3. Logistic models. Association between the amount of moderate-to-vigorous physical activity and optimal self-rated health, less health complaints and high satisfaction with life. Spanish adolescents aged 11–18 years, 2006.

	Men		Women		
	OR* (95% CI)	P	OR* (95% CI)	P	
Optimal self-rated health					
Frequency of undertaking MVPA					
Never	1 (ref)		1 (ref)		
1-2 days	2.37 (1.56 to 3.58)	<0.001	1.20 (0.85 to 1.69)		0.282
3-4 days	2.34 (1.44 to 3.81)	0.001	1.51 (1.06 to 2.14)		0.020
5-6 days	4.60 (2.60 to 8.13)	<0.001	2.28 (1.47 to 3.52)		<0.001
7 days	4.05 (2.38 to 6.89)	<0.001	2.14 (1.37 to 3.34)		0.001
Linear trend P-value	<0.001		<0.001		
Quadratic trend P-value	0.325		0.850		
Less health complaints					
Frequency of undertaking MVPA					
Never	1 (ref)		1 (ref)		
1-2 days	1.66 (1.14 to 2.42)	0.008	1.16 (0.90 to 1.49)		0.226
3-4 days	1.65 (1.14 to 2.39)	0.007	1.21 (0.93 to 1.58)		0.143
5-6 days	2.09 (1.47 to 2.96)	<0.001	1.46 (1.10 to 1.93)		0.009
7 days	1.94 (1.38 to 2.73)	<0.001	1.32 (0.97 to 1.80)		0.076
Linear trend P-value	0.001		0.021		
Quadratic trend P-value	0.216		0.463		
High satisfaction with life					
Frequency of undertaking MVPA					
Never	1 (ref)		1 (ref)		
1-2 days	1.99 (1.20 to 3.31)	0.007	0.93 (0.63 to 1.36)		0.722
3-4 days	1.52 (0.90 to 2.55)	0.111	1.44 (0.99 to 2.10)		0.056
5-6 days	2.02 (1.17 to 3.49)	0.011	1.56 (0.98 to 2.49)		0.059
7 days	1.94 (1.09 to 3.44)	0.023	2.00 (1.19 to 3.35)		0.008
Linear trend P-value	0.128		<0.001		
Quadratic trend P-value	0.661		0.975		

* Adjusted for age, country of birth, smoking, alcohol consumption, BMI, consumption of fruit and vegetables, daily breakfast, time spent watching TV using computers, time spent studying, academic achievement, employment situation of the father and mother, socioeconomic status, country of birth of the father and mother, type of household, number of adults and number of minors in the household, satisfaction with family relationships and with friends.

Table 4. Linear models. Association between the amount of moderate-to-vigorous physical activity and health-related quality of life. Spanish adolescents aged 11–18 years, 2006.

	Men		Women	
	β * (95% CI)	P	β * (95% CI)	P
Frequency of undertaking MVPA				
Never	0 (ref)		0 (ref)	
1-2 days	1.61 (0.29 to 2.93)	0.017	0.19 (- 0.71 to 1.10)	0.676
3-4 days	1.87 (0.50 to 3.24)	0.007	1.19 (0.37 to 2.02)	0.005
5-6 days	3.03 (1.74 to 4.31)	<0.001	2.79 (1.76 to 3.82)	<0.001
7 days	5.08 (3.73 to 6.43)	<0.001	5.09 (3.86 to 6.32)	<0.001
Linear trend P-value	<0.001		<0.001	
Quadratic trend P-value	0.006		<0.001	

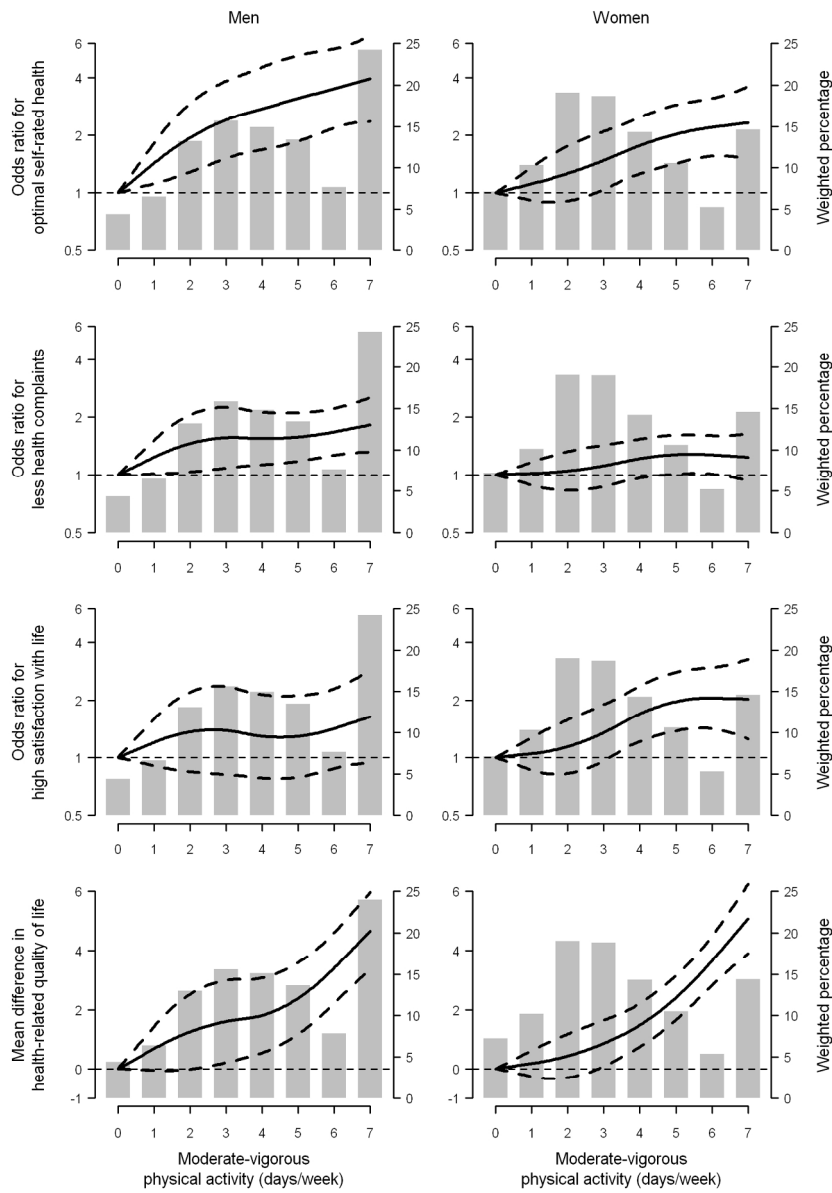
* Adjusted for age, country of birth, smoking, alcohol consumption, BMI, consumption of fruit and vegetables, daily breakfast, time spent watching TV and using computers, time spent studying, academic achievement, employment situation of the father and mother, socioeconomic status, country of birth of the father and mother, type of household, number of adults and number of minors in the household, satisfaction with family relationships and with friends.

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3 Figure 1. Dose-response relationship of the amount of self-reported Moderate-to-
4 Vigorous Physical Activity (MVPA) with optimal self-rated health, less health
5 complaints, high satisfaction with life, and health-related quality of life among Spanish
6 adolescents aged 11–18 years.
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11 *Footnote:*

12 Curves represent adjusted odds ratios or mean differences (solid lines) and their 95%
13 confidence intervals (dashed lines) based on restricted quadratic splines for the amount
14 of MVPA with knots at 1, 3.5, and 6 days/week. The reference value (odds ratio = 1 and
15 mean difference = 0) was set at 0 days/week of moderate-vigorous physical activity.
16 Odds ratios and mean differences were obtained from logistic and linear regression
17 models accounting for the complex survey and adjusted for personal and familial risk
18 factors (see Methods). Bars represent the weighted bar charts of the amount of MVPA
19 among men and women.
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Dear Editor,

We appreciate the suggestions and comments, which have helped us to improve the manuscript. Please find below the response to each individual comment and a detailed description of the changes made in the manuscript.
We have highlighted in blue the response to the reviewers and in red the changes in the manuscript.

Yours sincerely,

Iñaki Galán
Corresponding author

Reviewer: Allana LeBlanc
PhD (candidate)
Healthy Active Living and Obesity Research Group
Canada

The author should work with others to improve the overall flow of the manuscript.

With respect to Tables 1 and Table 2, you've presented a great deal of information that doesn't relate directly to your research question and is not spoken to in-text. This makes the tables very long and takes a great deal of time to work through. It is suggested you either reduce the information you present in the tables such that it reflects more concisely what you have spoken to in the text, or you divide up the tables in such a way that it is easier for the reader to orientate to.

Authors:

In these tables, we only describe the characteristics of the sample in relation to dependent variables. As you can see, the information corresponds to the crude analysis of the data, emphasizing that most of the relationships are statistically significant. We did not describe this information in the text because, except for MVPA (the main independent variable), all of them were considered as potentially confounding variables. This has been now stated in the text to make it clear to the reader. Nevertheless, to reduce information, the columns corresponding to the number of individuals have been deleted, maintaining the totals in the subheadings of the columns.

New sentence: The rest of potentially confounding variables considered, were also associated with self-rated health, less health complaints, high satisfaction with life and health-related quality of life (Tables 1 and 2).

No reporting guidelines were provided therefor unable to tell if they are in line/with which guidelines

Authors:

The following text has been added in the Introduction, replacing “Although it is recommended that all adolescents should undertake Moderate-to-Vigorous Physical Activity (MVPA) on most days of the week,…”

1
2
3 New sentence: "Although the World Health Organization (WHO) recommends that all
4 children of 5-17 years of age take at least 60 minutes of daily Moderate-to-Vigorous
5 Physical Activity (MVPA),¹⁸ ..." World Health Organization. *Global recommendations*
6 *on physical activity for health. World Health Organization 2010.*
7 http://whqlibdoc.who.int/publications/2010/9789241599979_eng.pdf.

8
9
10 I would like to congratulate you on putting together a manuscript that was quite
11 interesting to read. Some considerations...

12
13 Major points

14 - there is not enough justification for the use of self-report data. You have one sentence
15 to this point in the discussion and it is unclear what you are eluding to ("although it has
16 been an acceptable validation in our geographical coverage"). This was better explained
17 in the "article summary".

18
19
20 Authors:

21 Thank you for pointing out this limitation of the study. We have rewritten the text in the
22 Limitations subsection (Discussion): Second, the measurement of health status, MVPA
23 and several covariables of the study is based on self-reported information. Although it is
24 difficult to anticipate the magnitude and direction of the bias induced by measurement
25 error in self-reported physical activity without validity or reproducibility substudies,
26 some degree of attenuation in the underlying trends would be expected if the
27 misclassification of physical activity status was nondifferential with respect to health
28 outcomes. Nevertheless, the measurement of health status using subjective health scales,
29 as in this present study, has been validated in previous studies,^{20,23,24,39,40} and such scales
30 are considered to be useful tools especially in the stage of adolescence, when
31 psychological aspects are so important in the feeling of well-being among young
32 people. The variable used for estimating MVPA has been previously validated in an
33 adolescent population of Spain, obtaining an acceptable level of validity when
34 compared with measurement using accelerometers.²⁵ Other variables, such as self-
35 reported BMI or tobacco consumption, have also been validated in Spain, by comparing
36 them with objective measurements.^{41,42}

37
38
39 - to this, I find that at least some of the health related differences between boys and girls
40 is due to gender differences in perception of physical activity and not the associated
41 indicator of health

42
43
44 Authors:

45 We cannot rule out that some of the health related differences between boys and girls is
46 due to gender differences in perception of physical activity. The evidence in the general
47 population supporting the role of physical activity in the primary prevention of
48 cardiovascular disease and diabetes is now seen to be as strong for women as it is for
49 men, and the evidence supports an inverse dose-response relationship (*Brown WJ,*
50 *Burton NW, Rowan PJ. Updating the evidence on physical activity and health in*
51 *women. Am J Prev Med. 2007 Nov;33(5):404-411*). However, evidence about the effect
52 on health status using subjective health scales is scarce, above all in adolescents.

53
54
55 - looking at the data presented in Table 3, it seems that the majority of health effects
56 peak at 5-6 days, this is not addressed. It would have been interesting to see if it's at 5 or
57 6 days that you see the true peak.

Authors:

You can see in the Figure 1 the dose-response relationship for each day of undertaking MVPA, using smooth dose-response curves based on restricted quadratic splines. In Tables 3-4, they were grouped into five categories to be able to estimate odds ratios with greater statistical power.

- most of your sample reported very high levels of health - it may be that you're only seeing significance in the relationship with MVPA because your sample size is so large

Authors:

We agree with the reviewer that sample size used in the survey facilitates statistical significance in the relationships. However, the magnitude, dose-response, and consistency between the four indicators support the association.

- have you calculated if there is a difference in those whom you have complete data on and those whom you have incomplete data (i.e. family SES, activity level, reported health)

Authors:

The sample used to analyse the data of this study, excluding missing values, was similar to the original sample. We attach below, comparisons between these two samples by gender, age, socioeconomic status, health status, and the frequency of undertaking MVPA.

The following text has been incorporated at the end of the first paragraph of Data analysis, in Methods section: **The sample excluding missing values was similar to the original, comparing the main socioeconomic variables, health status, and the frequency of undertaking MVPA.**

Gender. Original sample size

Number of obs = 21811

	Proportion	Linearized Std. Err.
Gender		
Male	.4692203	.0093204
Female	.5307797	.0093204

Sample size excluding missing data

Number of obs = 17467

	Proportion	Linearized Std. Err.
Gender		
Male	.4560236	.0098674
Female	.5439764	.0098674

Age. Original sample size

Number of obs = 21811

	Mean	Linearized Std. Err.
Age	14.47145	.1519659

Sample size excluding missing data

Number of obs = 17467

	Mean	Linearized Std. Err.
Age	14.61931	.1545347

Socioeconomic status. Original sample size

Number of obs = 21537

	Proportion	Linearized Std. Err.
Socioeconomic Status		
Low	.1579951	.0072041
Average	.4647503	.0079537
High	.3772545	.0126104

Sample size excluding missing data

Number of obs = 17467

	Proportion	Linearized Std. Err.
Socioeconomic Status		
Low	.1503122	.0072175
Average	.465247	.0080808
High	.3844407	.012937

Optimal self-rated health. Original sample size

Number of obs = 21633

	Proportion	Linearized Std. Err.
No optimal	.0910135	.0041122
Optimal	.9089865	.0041122

Sample size excluding missing data

Number of obs = 17467

	Proportion	Linearized Std. Err.
No optimal	.0889121	.004322
Optimal	.9110879	.004322

Frequency of undertaking physical activity (MVPA). Original sample size

Number of obs = 21034

Frequency	Proportion	Linearized Std. Err.
Never	.0598736	.0030626
1-2 days	.2507102	.0054253
2-3 days	.3190528	.00488
5-6 days	.1793832	.0041762
7 days	.1909802	.0058509

Sample size excluding missing data

Number of obs = 17467

Frequency	Proportion	Linearized Std. Err.
Never	.0587022	.0033718
1-2 days	.2499415	.0060667
2-3 days	.3192562	.0054461
5-6 days	.1821689	.0043098
7 days	.1899313	.0060428

- this data is almost 7 years old, are you worried it is already out of date?

Authors:

It is expected that the mechanism underlying the dose-response relationship between physical activity and health status will not vary in the short or medium term.

- I disagree with your statement on p12149-57 - you've shown in this manuscript that youth are reporting significantly better health when they engage in 5-6 days of at least 60 min of MVPA, that is actually a considerable amount of PA and may be VERY intimidating to a sedentary individual. The way this is written is quite contradictory to the message you are sending elsewhere in the manuscript.

Authors:

As suggested, we have clarified the message, adding the following sentence:

Nevertheless, the maximum benefits were obtained according to public health recommendations, so the message should be: "even a little is good; more is better."³⁶ (Lee IM. Dose-response relation between physical activity and fitness: even a little is good; more is better. JAMA 2007; 297, 2137-2139).

Minor points

1
2
3 - there are some formatting errors in the references
4

5 **Authors:**

6 We have checked the format of all references.
7

8 - headings on your figure for gender are different in tables versus figures (i.e.
9 males/females vs men/women)
10

11 **Authors:**

12 Thank you for drawing our attention to this inconsistency. We have modified the labels
13 of this variable in the tables.
14

15
16 - many points throughout the manuscript where the writing is awkward and should be
17 worked on (e.g. p11,24-29, p11,52, p21,3-7, p12,49-57, p13,33-46, p14,29)
18

19 Following your recommendation, a native-English speaking copy editor and proofreader
20 has again reviewed the manuscript, paying special attention to the lines you mention
21 above. The following are examples of the changes made:
22

23
24 Discussion (first paragraph), the new amended text is: 1) the magnitude of the effect,
25 with benefits for optimal health reaching OR higher than 4 for males who undertook
26 MVPA daily or on most days, as compared to those who never undertook it;
27

28 Discussion: Dose-response relationship (last paragraph), the amended text follows: This
29 could have important implications for the preventive recommendations, because
30 (although 60 minutes of physical activity is currently recommended, if possible on a
31 daily basis) the fact that positive results of a moderate magnitude can be achieved with
32 very small amounts of MVPA may encourage the participation of the more sedentary
33 people.
34

35
36 Conclusions (first line): The sentence has been clarified by emphasizing that the MVPA
37 is "self-reported".
38

39 - you are inconsistent with your use of MVPA vs PA
40

41 **Authors:**

42 We have added MVPA instead of PA when referring to our data.
43
44

45 **Reviewer: Kirsten Corder**

46 Position: Investigator Scientist

47 Institution: MRC Epidemiology Unit, Cambridge, UK

48 I have no competing interests to declare.
49

50
51 This paper describes dose response associations between self-reported MVPA and self-
52 reported health indicators among a very large sample of Spanish adolescents. The
53 authors identify positive dose-response associations between self-reported MVPA and
54 health which appear to be stronger among males. This is an interesting research
55 question in a large sample; I have some comments which will hopefully be helpful in
56 clarifying the manuscript.
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3 Overall comments

4 Throughout the manuscript, the authors should be careful to clarify that this study
5 examines associations between two sets of self-reported variables. Clarification of this
6 in the title, abstract (e.g. objective and outcomes) and throughout would be useful.
7

8 Authors:

9 As suggested, we have emphasized throughout the manuscript that measurements are
10 self-reported variables.
11

12 Specific comments

13 Abstract results – ‘improvement’ should really be rephrased, perhaps to ‘association’ as
14 this study is cross-sectional.
15

16 Authors:

17 As suggested we have modified the text, including the following sentence: As the
18 frequency of MVPA increased, the association with health benefits was stronger.
19

20 Article summary

21 Article focus – clarification of the specific PA guidelines for adolescents (e.g. 60 mins
22 of MVPA) would be helpful.
23

24 Authors:

25 As suggested we have added the following text in the Article summary: “Although it is
26 recommended that all adolescents should undertake 60 minutes of daily Moderate-to-
27 Vigorous Physical Activity (MVPA)...”
28

29 Strengths/limitations – the self-report nature of the data is a major limitation and should
30 be included here.
31

32 Authors:

33 This major limitation is included in the last point of the Article summary: “A major
34 limitation is the cross-sectional nature of the study. Moreover, the measurement of
35 health status using subjective health scales and the estimation of MVPA are both based
36 on self-reported information”.
37

38 Introduction

39 Paragraph 2 – the authors state that there is little previous research examining MVPA
40 and health, however the authors refer to some in the discussion (Iannotti et al) which
41 perhaps should be included here. Additionally, Ekelund et al., JAMA 2012 is relevant to
42 add here. More specific details about the PA recommendations would also be relevant
43 to add here.
44

45 Authors:

46 We have included the following paragraph:
47 Ekelund et al.,¹⁷ in a pooled data analysis of 14 studies in children and adolescents,
48 found a direct benefit between three tertiles of Moderate-to-Vigorous Physical Activity
49 (MVPA) in relation to cardiometabolic outcomes
50

51 Paragraph 3 – it would be helpful to elaborate or give examples for ‘special
52 characteristics’; this sentence could also benefit from clarification.
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3 Authors:

4 The sentence has been rewritten, as follows:

5 It should be emphasized that concepts underlying health status in children and
6 adolescents differ from those for adults. As young people are still developing, the
7 measurement of health status must be approached from a global and comprehensive
8 perspective for each individual.
9

10 It is worthy of explanation as to why was only the Spanish HSBC sample used in this
11 analysis.
12

13
14 Authors:

15 We had previously investigated the dose-response relationship between PA and self-
16 reported health in an adult population of Spain. We wanted to reproduce this analysis in
17 adolescents living in a similar environment, so taking into account the large sample size
18 we decided to analyse the information from the HBSC of Spain.
19

20
21 Methods

22 Ethics approval for this study should be stated clearly.
23

24 Authors:

25 We have included this phrase in Methods section: This study was approved by the
26 Institutional Review Board of the Carlos III Institute of Health.
27

28 Study population – more detail about how the multistage sampling, and how that took
29 all of the listed factors into account is necessary as this is not currently clear from the
30 information provided.
31

32
33 Authors:

34 We have added more information, as follows: “A multistage stratified random sampling
35 was used, taking into account age strata (4 groups), region (17 autonomous
36 communities), school site (rural and urban), and type of school (public and private).
37 Initially, 480 schools were contacted of which 377 (103 private and 274 public schools)
38 agreed to participate in the study, which represented a response rate of 78.5%. On
39 average, three classes were selected in each school”
40

41 Page 7, end of first paragraph. More detail about the standardisation of these scores
42 would be relevant.
43

44
45 Authors:

46 We have added the following text: The items fulfil the assumptions of the Rasch model.
47 To make the interpretation more applicable, the scores of the Rasch scales are translated
48 into T-values with scale means of 50 and standard deviation of 10, with higher values
49 indicating higher health-related quality of life.²⁴
50

51
52 Page 7, second paragraph. Some information about the validity of the MVPA question
53 is necessary here.
54

55 Authors:
56
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2
3 As suggested, we have included the text as follows: This question, when compared with
4 PA assessed by accelerometers in Spanish adolescents, has shown an acceptable
5 validation.²⁵
6

7 There are many potential confounders included. It would be helpful to include rationale
8 for the inclusion of these, and more information about their measurement.
9

10 Authors:

11 As can be seen in the article of Sallis et al. (2000), cited in the paper, there are many
12 determinants of physical activity in children and adolescents. These variables are
13 potential confounders because they are also related to health status (see Tables 1-2). For
14 this reason, we consider it relevant to include the pool of variables analysed in the
15 study.
16

17 We think that we provide sufficient information about these variables, taking into
18 account that they are not the main variables of the study. In Tables 1-2, the categories of
19 the variables are described in detail. However, should the reviewers or the editor
20 consider it to be necessary, we would gladly add more information about their
21 measurement.
22

23 Data analysis

24 The authors state that the “Survey Data” module of STATA was used for analyses;
25 however, some explanation of what this function actually does is necessary.
26
27

28 Authors:

29 The following sentence has now been added: Standard errors were computed by using
30 the linearized variance estimator based on a first-order Taylor series.
31

32 More detail about how the confounding variables were included in the models is
33 necessary e.g. were these all added at once, were they added/removed stepwise? What
34 happened if they were / were not significant?
35
36

37 Authors:

38 We have included this information: All of these co-variables were added simultaneously
39 into the models.
40

41 Clarification of the outcome and exposure variables in each model would be helpful in
42 this section.
43
44

45 Authors:

46 We consider that the specification of the model can be seen in Tables 3 and 4.
47 Nevertheless, we have changed the text in the Data analysis section (Methods section),
48 as follows: Regression models were used, logistic ones for the estimation of the odds
49 ratio of prevalence (OR) and linear ones for the calculation of the regression coefficients,
50 adjusting for the potential confounding variables mentioned above. All co-variables were
51 added simultaneously into the models. First, we calculated the association between the
52 frequency of undertaking MVPA and health status by estimating OR for the following
53 categories: 1-2 days, 3-4 days, 5-6 days, and 7 days, using ‘never’ as the reference.
54 Second, linear and quadratic trends of the association between MVPA and the health
55 indicators were calculated from the regression models. For the linear trend, the average
56 value for each category was used modelling it as a continuous variable, while for the
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quadratic trend the square of these values was used. Statistical significance was set at $p < 0.05$.

The authors describe methods for assessing quadratic trends. The data is all self-reported but the data is analysed with complicated models and this limitation should at least perhaps be mentioned in the manuscript.

Authors:

In the manuscript, the self-reported nature of the variables used in our study was highlighted as a major limitation. However, nonlinear dose-response models are frequently used to analyze risk trends associated to self-reported life-style and dietary factors (Carroll RJ, Ruppert D, Stefanski LA. *Measurement error in nonlinear models*. Boca Raton, FL: Chapman and Hall/CRC, 1995). Although it is difficult to anticipate the magnitude and direction of the bias induced by measurement error in self-reported physical activity without validity or reproducibility substudies, some degree of attenuation in the underlying trends would be expected if the misclassification of physical activity status was nondifferential with respect to health outcomes.

Results

It would be helpful to report differences in descriptive data for those with missing data compared to those included in analyses.

Authors:

Please see the detailed answer given to the first reviewer. The sample used to analyse the data of this study, excluding missing values, was similar to the original sample. We attach comparisons between these two samples by gender, age, socioeconomic status, health status, and the frequency of undertaking MVPA.

Authors report no significant interactions between MVPA and age. This is perhaps unexpected due to the previously reported age-related PA decline throughout adolescents. It is therefore relevant to mention this in the discussion.

Authors:

It is well known that PA declines with age. However, age does not interact with MVPA to change the relationship with health status.

Page 9. End of last paragraph. A brief explanation of the nature of the sex-MVPA interaction would be useful here.

Authors:

We think that the description of the interaction belongs with the results of the study and that, therefore, it is more appropriate to describe it in the Results section.

Top of Page 10. The authors mention stratified analyses. Presumably analyses were stratified after significant interactions were identified? This should be clarified.

Authors:

This is explained in the last paragraph of the Methods section: *Interactions between MVPA, age and sex were evaluated. Given that interactions were found in the*

1
2
3 *relationship between the frequency of MVPA and health status according to sex, the*
4 *results are shown separately for men and women.*

5
6
7 Discussion

8 Terminology like 'protective effect' (top of page 11) and 'cause' (bottom of Page 11)
9 should be rephrased due to the cross-sectional nature of the study.

10
11 Authors:

12 This has been carried out with the text rephrased as follows:

13 - Top of page 11 (original version): "In females, the benefits were lower at low levels of
14 frequency of MVPA".

15 - Bottom of Page 11 (original version): "The dose-response relationship between PA
16 and health implies that increases in PA are related with additional improvements in
17 health status"

18
19
20 Bottom of page 13. The limitation regarding measurement bias is probably the major
21 limitation of this study and more explanation about how this may have influenced the
22 results is necessary.

23
24 Authors:

25 We have rewritten the text as follows:

26
27 Second, the measurement of health status, MVPA and several covariables of the study is
28 based on self-reported information. Although it is difficult to anticipate the magnitude
29 and direction of the bias induced by measurement error in self-reported physical activity
30 without validity or reproducibility substudies, some degree of attenuation in the
31 underlying trends would be expected if the misclassification of physical activity status
32 was nondifferential with respect to health outcomes. Nevertheless, the measurement of
33 health status using subjective health scales, as in this present study, has been validated
34 in previous studies,^{20,23,24,39,40} and such scales are considered to be useful tools
35 especially in the stage of adolescence, when psychological aspects are so important in
36 the feeling of well-being among young people. The variable used for estimating MVPA
37 has been previously validated in an adolescent population of Spain, obtaining an
38 acceptable level of validity when compared with measurement using accelerometers.²⁵
39 Other variables, such as self-reported BMI or tobacco consumption, have also been
40 validated in Spain, by comparing them with objective measurements.^{41,42}

41
42
43 First paragraph Page 14. The authors state that the standard methodology across HSBC
44 implies international comparability. A standard methodology does not imply this unless
45 a comparison has been made across this standard methodology. The authors should
46 therefore consider rephrasing this.

47
48 Authors:

49 We have deleted this phrase in the new version of the manuscript.

50
51
52 Conclusions

53 These should be 'toned-down' due to the self-report nature of this data.

54
55 Authors:

56 As suggested, we have toned-down the words taking into account the self-reported
57 nature of the data:
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59
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1
2
3 To sum up, an association was found between the frequency of undertaking self-
4 reported MVPA and the health status of adolescents enrolled in schools in Spain. A
5 linear trend was found for self-rated health, health complaints and for satisfaction with
6 life. For health-related quality of life the relationship was quadratic. The benefits of
7 MVPA on health were detected from very low levels, below those established by
8 current recommendations. In general, the magnitude of association was lower in females
9 than in males, a finding that needs to be explained by subsequent research.
10

11 Tables and figures

12 There is a lot of information presented in Tables 1 and 2. It is hard to get an overview of
13 this information and perhaps simplifying these tables by not presenting this separately
14 for health outcomes may be preferable.
15

16 Authors:

17 To reduce information, the columns corresponding to the number of individuals have
18 been deleted, maintaining the totals in the subheadings of the columns.
19

20 It would be helpful to plot the OR and Beta results in Tables 3 and 4 as figures with
21 95% CI. This would allow the reader a better overview of the main results.
22

23 Authors:

24 We preferred to plot the relationship between PA and health status without imposing
25 any particular function form the dose-response trends, based on regression models using
26 restricted quadratic splines (Figure 1).
27

28 It is apparent from the figures that relatively few participants reported doing 60 mins of
29 MVPA 6 days per week (compared to 5 or 7). Could the authors comment on whether
30 this is likely to be an artefact of self-reported data (e.g. participants who think they are
31 active most days select 7 days rather than 6) or due to real differences?
32

33 Authors:

34 We do not have arguments to consider this to be an artefact of self-reported data
35 although we cannot rule out this possibility. Males and females of all ages describe this
36 distribution.
37

38 Literature

39 The authors state that there is little previous research examining MVPA and health,
40 however the authors refer to some in the discussion (Iannotti et al) which perhaps
41 should be included here. Additionally, Ekelund et al., JAMA 2012 is relevant to add
42 here. More specific details about the PA recommendations would also be relevant to
43 add here.
44

45 Authors:

46 We have included these references in the manuscript.
47

48 Reviewer: David Crawford

49 Head, School of Exercise and Nutrition Sciences
50 Deakin University
51 Australia
52

1
2
3 This is a well written paper based on findings from a large population based study, in
4 an under-studied group, namely adolescents. The major limitation of this paper is its
5 cross-sectional study design, and while this is acknowledged by the authors, it is a
6 major weakness.
7

8 The cross-sectional nature of this study is a major weakness - eg possibility of reverse
9 causality.
10

11 **Authors:**

12 We agree with the reviewer. We have highlighted this major limitation in the
13 manuscript, especially in the Discussion section (first paragraph of Strengths and
14 weaknesses).
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Physical activity and health status among adolescents: a cross-sectional population-based study

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Secondary Subject Heading:	Sports and exercise medicine
Keywords:	Physical activity, Health status, Adolescents

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3 **Physical activity and self-reported health status among adolescents: a cross-sectional**
4 **population-based study**
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43

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Abstract

Objectives: Little is known about the dose-response relationship between physical activity and health benefits among young people. Our objective was to analyse the association between the frequency of undertaking Moderate-to-Vigorous Physical Activity (MVPA) and the self-reported health status of the adolescent population.

Design: Cross-sectional study.

Setting: All regions of Spain.

Participants: Students aged 11-18 years participating in the Spanish Health Behaviour in School-aged Children (HBSC) survey 2006. A total of 375 schools and 21,188 students were selected.

Main outcomes: The frequency of undertaking MVPA was measured by questionnaire, as were the following four health indicators: self-rated health, health complaints, satisfaction with life, and health-related quality of life. Linear and logistic regression models were used to analyse the association, adjusting for potential confounding variables and the modelling of the dose-response relationship.

Results: As the frequency of MVPA increased, the association with health benefits was stronger. A linear trend ($p < 0.05$) was found for self-rated health and health complaints in males and females, and for satisfaction with life among females; for health-related quality of life, this relationship was quadratic for both sexes ($p < 0.05$). For self-reported health and health complaints, the effect was found to be of greater magnitude in males than in females and, in all scales, the benefits were observed from the lowest frequencies of MVPA, especially in males.

Conclusions: A protective effect of MVPA was found in both sexes for the four health indicators studied, and this activity had a gradient effect. Among males, health benefits

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were detected from very low levels of physical activity and the magnitude of the relationship was greater than that for females.

For peer review only

Article summary

Article focus

- Although it is recommended that all adolescents should undertake 60 minutes of daily Moderate-to-Vigorous Physical Activity (MVPA), little is known about the nature of the relationship in this population, and whether or not the effect varies depending on age and sex.
- We examined cross-sectional associations between the frequency of undertaking self-reported MVPA and the health status of the adolescent population, using subjective health scales that are considered to be useful tools especially in the stage of adolescence, when psychological aspects are so important in the feeling of well-being among young people.

Key messages

- The protective effect of MVPA on health was detected from very low levels, below those established by current recommendations.
- A linear trend was found for self-rated health, health complaints and for satisfaction with life. For health-related quality of life the relationship was quadratic.
- The positive effect on health produced lower results in females than in males.

Strengths and limitations of this study

- The main strength is the representativeness and large size of the sample. The methodology employed is the standard one for the HBSC study in which more than 40 Western countries have participated.
- A major limitation is the cross-sectional nature of the study. Moreover, the measurement of health status using subjective health scales and the estimation of MVPA are both based on self-reported information.

INTRODUCTION

According to the World Health Organization (WHO)¹, physical inactivity is the fourth most important risk factor affecting global mortality, to which nearly 6% of all deaths are attributed. In the adolescent population, short-term benefits related to Physical Activity (PA) are improvements in lipid profile, blood pressure, metabolic syndrome, muscular strength and bone density, together with a reduction in obesity and overweight levels, as well as a decrease in emotional problems and depressive symptoms.²⁻⁵ Moreover, young people who undertake PA adopt healthy behaviour more easily and have better levels of academic achievement and cognitive functioning.^{4, 6-8}

The dose-response relationship between physical activity and various health indicators has mainly been studied in the adult population,⁹⁻¹⁵ where there is still a controversy about whether or not this relationship is linear.^{12,16} Ekelund et al.,¹⁷ in a pooled data analysis of 14 studies in children and adolescents, found a direct benefit between three tertiles of Moderate-to-Vigorous Physical Activity (MVPA) in relation to cardiometabolic outcomes. Although the WHO recommends that all children of 5-17 years of age take at least 60 minutes of daily MVPA,¹⁸ little is known about the nature of the relationship in this population. Therefore, finding out the effect on health of several levels of PA could have important implications for improving the recommendations regarding this activity.

It should be emphasized that concepts underlying health status in children and adolescents differ from those for adults. As young people are still developing, the measurement of health status must be approached from a global and comprehensive perspective for each individual. Concepts such as 'subjective health' and 'health-related quality of life' cover complex physical, emotional, mental and social aspects.^{19,20} Hence,

1
2
3 it is important to evaluate if the effect of the PA is distributed in a distinct way for the
4
5 different dimensions of health status.
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8 Finally, although PA varies considerably depending on age and sex,²¹ to our knowledge
9
10 there have been very few studies in the literature about the role that these variables play
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12 regarding the effect of PA on health.⁴
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15 The objective of this study was to analyse the association between the frequency of
16
17 undertaking MVPA and the different dimensions of adolescent health status, assessing if
18
19 this relationship differs according to age and sex.
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22 23 24 25 **METHODS**

26 27 **Study population**

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30 The source of information was the Health Behaviour in School-aged Children (HBSC)
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32 study carried out in 2006.²² The population was a representative sample of
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34 preadolescents and adolescents, with an age range of 11-18 years, resident in Spain and
35
36 enrolled in school from the 5th year of primary school to the last year of upper
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38 secondary school (2nd year of baccalaureate). A multistage stratified random sampling
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40 was used, taking into account age strata (4 groups), region (17 autonomous
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42 communities), school site (rural and urban), and type of school (public and private).
43
44 Initially, 480 schools were contacted of which 377 (103 private and 274 public schools)
45
46 agreed to participate in the study, which represented a response rate of 78.5%. On
47
48 average, three classes were selected in each school. A total of 22,350 questionnaires
49
50 were collected, although subsequently 539 were excluded because of non-response to
51
52 questions about sex and age, or lack of response to more than 50% of the questionnaire.
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57 The sample size was 21,811 participants. The study was carried out in spring 2006.
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3 Previously trained survey technicians visited the selected schools, where the students
4
5 completed an anonymous questionnaire during normal school hours.
6

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8 This study was approved by the Institutional Review Board of the Carlos III Institute of
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10 Health .

11 12 **Study variables**

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15 Health status was measured using four indicators: 1) self-rated health was measured using
16
17 the question “*Would you say that your health is: excellent, good, fair or bad*”. Optimal
18
19 health status was categorized by a response of excellent or good, and sub-optimal health
20
21 status was categorized by a response of fair or bad. 2) The health complaints indicator
22
23 was assessed using a scale based on the HBSC-Symptom Checklist, which is a list of
24
25 eight physical and psychological symptoms (headaches, abdominal pain, backache,
26
27 feeling low, irritability, nervousness, sleeping difficulties and dizziness), to estimate their
28
29 frequency during the last six months. Having 2 or more symptoms with a frequency of
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31 several times a week or daily was considered to define having noticeable subjective
32
33 health complaints.¹⁹ 3) Satisfaction with life was estimated using the Cantril Ladder,²³ in
34
35 which, using a scale from 0 to 10, the participant was asked “*on which rung of the ladder*
36
37 *(scale from 0 to 10) do you feel you stand at this moment in your life?*”, with 0 being the
38
39 worst score and 10 the best. A score of 0 to 5 was categorized as dissatisfied, whereas a
40
41 score of 6 to 10 was categorized as satisfied.¹⁹ 4) Health-related quality of life was
42
43 measured using the Kidscreen-10 index,²⁴ a series of 10 questions about mood, ability to
44
45 concentrate, energy, vitality, well-being, ability to have fun with friends. Each question
46
47 has five categories of response ranging from “never” to “always” or from “not at all” to
48
49 “extremely often”. The items fulfil the assumptions of the Rasch model. To make the
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51 interpretation more applicable, the scores of the Rasch scales are translated into T-values
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3 with scale means of 50 and standard deviation of 10, with higher values indicating higher
4 health-related quality of life.²⁴
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8 The frequency of MVPA was measured using the question: “*in the last seven days,*
9 *considering moderate and vigorous activity... On how many days did you feel you were*
10 *physically active for a total of 60 minutes per day?*” The response categories were from 0
11 to 7 days. This question, when compared with PA assessed by accelerometers in Spanish
12 adolescents, has shown an acceptable validation (Spearman correlation=0.43).²⁵
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19 The following factors were considered as potentially confounding variables for the
20 association between health status and frequency of MVPA: 1) personal variables (sex,
21 age, country of birth, current smoker, alcohol consumption, body-mass index –calculated
22 as the ratio of weight in kg/height in m² from self-reported weight and height, and
23 defining overweight and obesity using the cut-off points proposed by Cole et al.,²⁶
24 consumption of fruit and vegetables, daily breakfast, number of hours each day spent
25 watching television and using computers or game consoles, number of hours each day
26 spent doing school homework); 2) family variables (employment status of the father,
27 employment status of the mother, family purchasing power –measured by the Family
28 Affluence Scale,²⁷ an index estimated by four items: number of times that the adolescents
29 have been on holiday with their family in the last 12 months; does the family own a car or
30 van; does the student have his/her own bedroom; number of computers owned by the
31 family-, country of birth of the father, country of birth of the mother, type of household –
32 both parents, single parent, blended family–, number of minors in the household, number
33 of adults in the household); and 3) relationships with the school, the family and friends
34 (academic achievement, satisfaction with family relationships, satisfaction with
35 relationships with friends). The variables are categorized in Table 1.
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Data analysis

The questionnaires with missing values were excluded from data analysis, so that the number of subjects studied was 17,467 for self-rated health; 17,358 for satisfaction with life; 16,803 for health complaints; and 16,560 for health-related quality of life. The sample excluding missing values was similar to the original (there was no statistically significant difference), comparing the main socioeconomic variables, health status, and the frequency of undertaking MVPA.

The complex sampling design was taken into account during analysis by using the “Survey Data” module of the statistical package Stata v11. Standard errors were computed by using the linearized variance estimator based on a first-order Taylor series. Prevalence was calculated for optimal self-rated health, low level of health complaints, high satisfaction with life, and the means for the scores on the scale for health-related quality of life, with 95% confidence intervals, both global and for the categories of each one of the exposure variables.

Regression models were used, logistic ones for the estimation of the odds ratio of prevalence (OR) and linear ones for the calculation of the regression coefficients, adjusting for the potential confounding variables mentioned above. All co-variables were added simultaneously into the models. First, we calculated the association between the frequency of undertaking MVPA and health status by estimating OR for the following categories: 1-2 days, 3-4 days, 5-6 days, and 7 days, using ‘never’ as the reference. Second, linear and quadratic trends of the association between MVPA and the health indicators were calculated from the regression models. For the linear trend, the average value for each category was used modelling it as a continuous variable, while for the quadratic trend the square of these values was used. Statistical significance was set at $p < 0.05$.

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3 To further explore the relationships between MVPA and health status indicators without
4 imposing any particular functional form for the dose-response trends, the amount of
5 moderate-to-vigorous physical activity was entered in regression models using restricted
6 quadratic splines with knots at 1, 3.5, and 6 days/week.²⁸ Restricted quadratic splines
7 allow for different quadratic trends within each intermediate category and linear trends in
8 boundary categories, and hence they can accommodate a wide variety of smooth dose-
9 response curves, while avoiding implausible shapes at the tails of the exposure
10 distribution.
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21 Interactions between MVPA, age and sex were evaluated. Given that interactions were
22 found in the relationship between the frequency of MVPA and health status according to
23 sex, the results are shown separately for males and females.
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31 RESULTS

32
33 Table 1 describes the health status of the questionnaire respondents, as estimated by the
34 four health indicators. A total of 91.1% (CI 95%: 90.3-92.0) declared they had an
35 optimal self-rated health, 67.4% (CI 95%: 66.1-68.5) had a low level of health
36 complaints and 90.9% (CI 95%: 90.1-91.6) reported a high satisfaction with life. The
37 mean score on the scale for health-related quality of life was 47.1 (CI 95%: 46.5- 47.6).
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45 According to all the indicators used, the level of health was better, in a statistically
46 significant way, for the questionnaire respondents who indicated that they undertook
47 MVPA more frequently, with gradual increases depending on the categories of MVPA
48 (Table 1). The rest of potentially confounding variables considered, were also associated
49 with self-rated health, less health complaints, high satisfaction with life and health-
50 related quality of life (Tables 1 and 2).
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3 No statistically significant interactions were found between MVPA and age, whereas
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5 statistical significance was reached between MVPA and sex for the indicators self-rated
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7 health and satisfaction with life.
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10 Tables 3 and 4 and Figure 1 show the results of the multivariate analysis that evaluated, for
11
12 each sex separately, the association of the frequency of undertaking MVPA with the
13
14 different indicators of health status, controlling the effect on this association of personal and
15
16 family factors. For both boys and girls, there was a positive, graded and statistically
17
18 significant association (linear trend, $p < 0.001$) between MVPA and self-rated health (Table
19
20 3), with odds ratios (OR) that ranged in males from 2.37, for those who undertook MVPA
21
22 on 1-2 days, to 4.60 and 4.05, for those undertaking it on 5-6 and 7 days, respectively.
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24 Moving from less than 5 days to 5-6 days of MVPA, the OR increased from 2.34 to 4.60. In
25
26 females, although a positive association was also found, the magnitude of the benefits on
27
28 self-reported health was lower, with values that were half those for the males (OR= 2.14, if
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30 MPVA undertaken 7 days).
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35 Regarding less health complaints (Table 3), an increase in the positive effects was seen in
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37 males from small amounts of MVPA on 1-2 days (OR=1.66, $p=0.008$), which increased
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39 further to an OR of nearly 2 for MVPA on 5-6 days. In females, this effect was lower,
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41 reaching statistical significance after MVPA on 5-6 days with an OR of 1.46 ($p=0.009$). The
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43 linear trend p-value was statistically significant ($p < 0.001$) in both males and females.
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46 The degree of satisfaction with life (Table 3) was also shown to be significantly associated
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48 with the frequency of undertaking MVPA; among the boys the OR for high satisfaction
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50 increased to 1.99 if physical activity was undertaken on 1-2 days per week, and satisfaction
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52 remained at these values for frequencies of more than 5 days of MVPA. In girls, the
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54 magnitude of the effect was similar, but the gradient was steeper. The linear trend p-value
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56 was statistically significant for females ($p < 0.001$), but not for males.
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3 Table 4 shows the same analysis applied to health-related quality of life, considering it
4 as a continuous variable and using linear regression to analyse it. In males, an increasing
5 dose-response effect was seen, especially noticeable after 5-days per week of MVPA
6 ($\beta=3.03$), which increased even further, to 5.08, for those undertaking MVPA for 7-days
7 per week. In females, the benefits were lower at low levels of frequency of MVPA, but
8 reached the same magnitude from 5 days of MVPA. Overall, this indicator was the one
9 that showed fewer differences between boys and girls, as can be seen in Figure 1. The
10 quadratic trend p-value was statistically significant in males ($p=0.006$) and females
11 ($p<0.001$).

22 23 24 25 26 **DISCUSSION**

27 28 **Principal findings**

29
30 The results of this study clearly show the benefits of undertaking physical activity on the
31 health status of adolescents enrolled in schools in Spain. The following results should be
32 highlighted: 1) the magnitude of the effect, with benefits for optimal health reaching OR
33 higher than 4 for males who undertook MVPA daily or on most days, as compared to
34 those who never undertook it; 2) the existence of a dose-response effect, with the
35 positive effects increasing in accordance with the increase in the frequency of MVPA; 3)
36 the consistency of the results with the association present for the four health indicators in
37 both sexes; and 4) the greater positive effect in males, especially at low levels of
38 frequency of MVPA.

39
40 Few studies have linked the effect of MPVA on general indicators of health status in
41 adolescents. Using data from the HBSC study for adolescents from North America,
42 Western Europe, Eastern Europe, Northern Europe and Southern Europe, Iannotti et al.²⁹
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3 evaluated the relationship between the frequency of PA and self-rated health, health
4 complaints and satisfaction with life and found, as in our study, beneficial effects for all
5 three indicators.
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9 10 **Dose-response relationship**

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12 The dose-response relationship between PA and health implies that increases in PA are
13 related with additional improvements in health status, even when it is not undertaken
14 very frequently. This has also been found in other studies regarding dyslipidemia, blood
15 pressure, overweight and obesity, metabolic syndrome and mental health.^{4,30-32} However,
16 to our knowledge, there are no comparable studies that measure the nature of the
17 relationship on general indicators of health status. Indeed, there is a controversy about
18 whether this relationship is linear or curvilinear, as some studies have found linear
19 patterns, whereas others have not,^{4,30-32} probably because the patterns can be different
20 depending upon the health effect that is being assessed. In our study, a curvilinear
21 relationship was found with a slight slowdown in the health benefits beyond 3-4 days of
22 MVPA in the following indicators: self-rated health; health complaints; and satisfaction
23 with life. In contrast, for health-related quality of life in both sexes, the benefits
24 increased from these intermediate levels of MVPA. These differences in the dose-
25 response relationship suggest that the effect varies depending upon the different
26 dimensions of health status to which the indicators are related. Although self-rated
27 health has been proposed as a measurement of the summary effect of multiple
28 dimensions of health, it is more closely related to the physical dimension rather than the
29 mental and social ones.³³ Similarly, the scale for health complaints is related to
30 symptoms with psychosomatic components very frequently associated with
31 adolescence.³⁴ Yet, the scale for the quality of life, besides including such physical and
32 mental dimensions, also incorporates family and social relationships, which could
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3 suggest that these additional dimensions may be involved in the achieving of greater
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5 health benefits with the maximum frequencies of MVPA.
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8 It should be stressed that the benefits to health status are obtained from low levels of
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10 MVPA, especially for boys. Similar results have been reported for self-rated health in a
11
12 young adult population³⁵ and regarding blood pressure and dyslipidemia in
13
14 adolescents.^{31,32} This could have important implications for the preventive
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16 recommendations, because (although 60 minutes of physical activity is currently
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18 recommended, if possible on a daily basis) the fact that positive results of a moderate
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20 magnitude can be achieved with very small amounts of MVPA may encourage the
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22 participation of the more sedentary people. Nevertheless, the maximum benefits were
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24 obtained according to public health recommendations, so the message should be: “even a
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26 little is good; more is better”.³⁶
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30 **Gender differences**

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33 The results in health that are derived from undertaking MVPA are greater in males,
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35 especially in self-rated health and, to a lesser extent, in having less health complaints.
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37 According to our study, females need to undertake more days of MVPA to obtain
38
39 similar health benefits. However, the effect on satisfaction with life and health-related
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41 quality of life was fairly similar in males and females. These differences suggest that the
42
43 variation of the effect of MVPA according to sex could also be associated to different
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45 dimensions of health status. Previous reviews have clearly shown important differences
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47 between males and females in the quantity, intensity and type of physical activity, and
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49 that, in part, these distinctions could be explained by biological differences and those
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51 relating to sociocultural environment and body image.^{21,37} It would, therefore, be
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53 interesting for subsequent studies to undertake detailed research about this relationship.
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58 **Strengths and weaknesses**

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3 To aid correct interpretation of these data, several limitations should be mentioned. First,
4
5 the limitation in causal inference, stemming from the cross-sectional nature of the study,
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7 would theoretically affect the temporality of the association. That is, people who have
8
9 health problems can have limitations in undertaking physical exercise. However, from
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11 the data of the National Health Survey of 2006,³⁸ only 1.7% of adolescents between 16
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13 and 19 years do not undertake the leisure time physical exercise that they would like to
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15 take because of health problems, hence, this figure would not affect the results obtained.
16
17 Second, the measurement of health status, MVPA and several covariables of the study is
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19 based on self-reported information. Although it is difficult to anticipate the magnitude
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21 and direction of the bias induced by measurement error in self-reported physical activity
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23 without validity or reproducibility substudies, some degree of attenuation in the
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25 underlying trends would be expected if the misclassification of physical activity status
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27 was nondifferential with respect to health outcomes. Nevertheless, the measurement of
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29 health status using subjective health scales, as in this present study, has been validated in
30
31 previous studies,^{20,23,24,39,40} and such scales are considered to be useful tools especially in
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33 the stage of adolescence, when psychological aspects are so important in the feeling of
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35 well-being among young people. The variable used for estimating MVPA has been
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37 previously validated in an adolescent population of Spain, obtaining an acceptable level
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39 of validity when compared with measurement using accelerometers.²⁵ Other variables,
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41 such as self-reported BMI or tobacco consumption, have also been validated in Spain, by
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43 comparing them with objective measurements.^{41,42} Third, it has not been possible to
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45 differentiate the effect of the intensity of physical activity, which is a dimension
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47 independently related with self-rated health.³⁵

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49 The main strengths of this study are the representativeness and large size of the sample
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51 used, which means that the results can be extrapolated accurately, and that the
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3 methodology employed is the standard one for the HBSC study. This is a collaborative
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5 WHO study in which more than 40 Western countries (including Spain) have
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7 participated.
8

9 10 **CONCLUSIONS**

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12 To sum up, an association was found between the frequency of undertaking self-reported
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14 MVPA and the health status of adolescents enrolled in schools in Spain. A linear trend
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16 was found for self-rated health, health complaints and for satisfaction with life. For
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18 health-related quality of life the relationship was quadratic. The benefits of MVPA on
19
20 health were detected from very low levels, below those established by current
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22 recommendations. In general, the magnitude of association was lower in females than in
23
24 males, a finding that needs to be explained by subsequent research.
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33
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35

36
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38
39 PR, FR and CM coordinated the field work and collected the data. IG, RB, MM and RP
40
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42
43 interpretation of data and revision of the manuscript. All authors approved the final
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45 version.
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47
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49
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51
52 of Health and Social Policy].
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55 **Competing interests:** None.
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3 **Ethics approval:** This study was approved by the Institutional Review Board of the
4
5 Carlos III Institute of Health.
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8 **Provenance and peer review:** Not commissioned; externally peer reviewed.
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10 **Data sharing statement:** Full results of the Spanish HBSC study are available at
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12 <http://www.msps.es/profesionales/saludPublica/prevPromocion/promocion/saludJovenes>
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14 [/estudioHBSC/nacional_hbsc.htm](http://www.msps.es/profesionales/saludPublica/prevPromocion/promocion/saludJovenes)
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Table 1. Description of the sample and distribution of optimal self-rated health, less health complaints, high satisfaction with life and health-related quality of life, according to individual variables. Spanish adolescents aged 11–18 years, 2006.

		Optimal Self-reported health N (17467)	Less health complaints N (16803)	High satisfaction with life N (17358)	Health-related quality of life N (16560)
		%	%	%	Mean
MVPA	Global	91.1	67.4	90.9	47.1
	Never	80.1*	54.1*	82.3*	42.6*
	1-2 days	87.5	62.8	87.4	44.3
	3-4 days	90.8	66.3	91.3	46.2
	5-6 days	94.8	72.8	93.1	48.2
Sex	7 days	95.9	74.1	95.2	52.5
	Men	93.3*	76.7*	91.9*	48.3*
Age	Women	89.3	59.5	90.0	46.1
	10-12	95.8*	68.6	94.9*	52.5*
	13-16	90.1	67.6	89.8	45.6
Born in Spain	17-18	86.8	65.1	87.7	43.2
	Yes	91.1	67.7*	91.2*	47.2
	No	91.2	62.9	85.3	45.7
Smoking	Non-smoker	94.5*	70.6*	94.0*	49.3*
	Smoker	80.9	56.6	83.7	42.8
	Ex-smoker	89.2	66.6	86.9	44.1
Consumption of alcohol	Never	95.4*	70.4*	94.3*	50.7*
	Rarely	89.9	65.2	88.9	45.4
	Monthly	88.1	66.3	87.2	43.5
	Weekly or daily	85.2	64.2	87.9	43.9
Body-mass index	Normal or underweight	92.5*	68.2*	91.5*	47.0
	Overweight	86.7	67.6	90.3	47.1
	Obese	77.4	58.0	83.0	46.6
	NR	90.4	64.6	89.4	47.2
Consumption of fruit and vegetables	Quartile 1	88.2*	64.1*	88.8*	45.8*
	Quartile 2	91.5	67.5	91.5	46.5
	Quartile 3	92.5	69.7	92.2	47.2
	Quartile 4	92.6	68.5	91.2	48.7
Breakfast during the week	Every day	93.2*	70.4*	92.6*	48.1*
	Not every day	85.5	59.1	86.1	44.3
Time spent TV and computers	Quartile 1	91.1	68.7*	91.5*	48.0*
	Quartile 2	91.1	69.4	91.8	47.0
	Quartile 3	91.7	68.8	91.5	47.0
	Quartile 4	90.2	62.8	88.7	46.2
	NR	92.6	65.4	89.3	48.6
Time spent studying/ homework	Quartile 1	89.3*	68.8*	87.1*	46.3*
	Quartile 2	92.2	69.3	91.9	47.9
	Quartile 3	92.4	68.8	92.5	47.7
	Quartile 4	90.5	62.9	91.5	46.3
	NR	89.4	69.3	88.6	48.4
Academic achievement	Very good	96.3*	71.8*	96.4*	52.4*
	Good	94.0	69.7	94.2	48.2
	Average	87.4	65.3	87.3	44.2
	Low	79.7	54.0	75.3	41.7

* $p < 0.05$

MVPA: Moderate-to-Vigorous Physical Activity

NR: Non-response

Table 2. Description of the sample and distribution of optimal self-rated health, less health complaints, high satisfaction with life and health-related quality of life, according to family variables. Spanish adolescents aged 11–18 years, 2006.

	Optimal Self-reported health N (17467)	Less health complaints N (16803)	High satisfaction with life N (17358)	Health-related quality of life N (16560)
	%	%	%	Mean
Employment situation of father				
Paid employment	91.5*	67.8*	91.3*	47.2*
No paid employment	86.9	63.0	85.4	45.4
Don't know	90.3	52.9	91.5	43.3
No father	85.4	59.8	82.0	44.3
Employment situation of mother				
Paid employment	91.0	67.1	90.8*	47.1*
No paid employment	91.5	68.3	91.4	47.0
Don't know	90.9	59.1	91.4	47.5
No mother	83.7	58.7	78.0	45.2
Socioeconomic status				
Low	86.2*	62.6*	84.5*	45.2*
Average	91.2	66.7	90.9	46.9
High	92.9	69.9	93.2	48.0
Country of birth of father				
Spain	91.1	67.6	91.2*	47.1
Other countries	91.1	64.7	86.2	46.4
Country of birth of mother				
Spain	91.1	67.7*	91.1*	47.1
Other countries	91.9	62.4	87.3	46.1
Type of household				
Both parents	92.0*	68.4*	91.9*	47.3*
Single parent	86.9	62.2	85.0	45.7
Blended	83.0	59.3	82.6	44.2
Others	85.3	61.3	86.8	46.8
Number of adults in the household				
2	91.7*	64.1*	91.2*	47.3
0,1,3,4,5	88.8	68.3	89.3	46.4
Number of minors in the household				
1,2,3	91.1	60.3*	91.0	47.1
>3	90.6	68.0	88.8	46.8
Satisfaction: family relationships ^a				
Good	93.0*	45.2*	94.2*	48.0*
Fair-bad	75.9	70.1	64.2	39.4
Satisfaction: relationships with friends ^a				
Good	92.0*	48.5*	92.3*	47.5*
Fair-bad	77.1	68.6	68.5	40.0

* $p < 0.05$

^a Good: score 7-10; Fair-bad: score 0-6

Table 3. Logistic models. Association between the amount of moderate-to-vigorous physical activity and optimal self-rated health, less health complaints and high satisfaction with life. Spanish adolescents aged 11–18 years, 2006.

	Men		Women		
	OR* (95% CI)	P	OR* (95% CI)	P	
Optimal self-rated health					
Frequency of undertaking MVPA					
Never	1 (ref)		1 (ref)		
1-2 days	2.37 (1.56 to 3.58)	<0.001	1.20 (0.85 to 1.69)	0.282	
3-4 days	2.34 (1.44 to 3.81)	0.001	1.51 (1.06 to 2.14)	0.020	
5-6 days	4.60 (2.60 to 8.13)	<0.001	2.28 (1.47 to 3.52)	<0.001	
7 days	4.05 (2.38 to 6.89)	<0.001	2.14 (1.37 to 3.34)	0.001	
Linear trend P-value	<0.001		<0.001		
Quadratic trend P-value	0.325		0.850		
Less health complaints					
Frequency of undertaking MVPA					
Never	1 (ref)		1 (ref)		
1-2 days	1.66 (1.14 to 2.42)	0.008	1.16 (0.90 to 1.49)	0.226	
3-4 days	1.65 (1.14 to 2.39)	0.007	1.21 (0.93 to 1.58)	0.143	
5-6 days	2.09 (1.47 to 2.96)	<0.001	1.46 (1.10 to 1.93)	0.009	
7 days	1.94 (1.38 to 2.73)	<0.001	1.32 (0.97 to 1.80)	0.076	
Linear trend P-value	0.001		0.021		
Quadratic trend P-value	0.216		0.463		
High satisfaction with life					
Frequency of undertaking MVPA					
Never	1 (ref)		1 (ref)		
1-2 days	1.99 (1.20 to 3.31)	0.007	0.93 (0.63 to 1.36)	0.722	
3-4 days	1.52 (0.90 to 2.55)	0.111	1.44 (0.99 to 2.10)	0.056	
5-6 days	2.02 (1.17 to 3.49)	0.011	1.56 (0.98 to 2.49)	0.059	
7 days	1.94 (1.09 to 3.44)	0.023	2.00 (1.19 to 3.35)	0.008	
Linear trend P-value	0.128		<0.001		
Quadratic trend P-value	0.661		0.975		

* Adjusted for age, country of birth, smoking, alcohol consumption, BMI, consumption of fruit and vegetables, daily breakfast, time spent watching TV using computers, time spent studying, academic achievement, employment situation of the father and mother, socioeconomic status, country of birth of the father and mother, type of household, number of adults and number of minors in the household, satisfaction with family relationships and with friends.

Table 4. Linear models. Association between the amount of moderate-to-vigorous physical activity and health-related quality of life. Spanish adolescents aged 11–18 years, 2006.

	Men		Women	
	β * (95% CI)	P	β * (95% CI)	P
Frequency of undertaking MVPA				
Never	0 (ref)		0 (ref)	
1-2 days	1.61 (0.29 to 2.93)	0.017	0.19 (- 0.71 to 1.10)	0.676
3-4 days	1.87 (0.50 to 3.24)	0.007	1.19 (0.37 to 2.02)	0.005
5-6 days	3.03 (1.74 to 4.31)	<0.001	2.79 (1.76 to 3.82)	<0.001
7 days	5.08 (3.73 to 6.43)	<0.001	5.09 (3.86 to 6.32)	<0.001
Linear trend P-value	<0.001		<0.001	
Quadratic trend P-value	0.006		<0.001	

* Adjusted for age, country of birth, smoking, alcohol consumption, BMI, consumption of fruit and vegetables, daily breakfast, time spent watching TV and using computers, time spent studying, academic achievement, employment situation of the father and mother, socioeconomic status, country of birth of the father and mother, type of household, number of adults and number of minors in the household, satisfaction with family relationships and with friends.

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3 Figure 1. Dose-response relationship of the amount of self-reported Moderate-to-
4 Vigorous Physical Activity (MVPA) with optimal self-rated health, less health
5 complaints, high satisfaction with life, and health-related quality of life among Spanish
6 adolescents aged 11–18 years.
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11 *Footnote:*

12 Curves represent adjusted odds ratios or mean differences (solid lines) and their 95%
13 confidence intervals (dashed lines) based on restricted quadratic splines for the amount
14 of MVPA with knots at 1, 3.5, and 6 days/week. The reference value (odds ratio = 1 and
15 mean difference = 0) was set at 0 days/week of moderate-vigorous physical activity.
16 Odds ratios and mean differences were obtained from logistic and linear regression
17 models accounting for the complex survey and adjusted for personal and familial risk
18 factors (see Methods). Bars represent the weighted bar charts of the amount of MVPA
19 among men and women.
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3 **Physical activity and self-reported health status among adolescents: a cross-sectional**
4 **population-based study**
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41 **Keywords:** Physical activity, health status, adolescents
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Abstract

Objectives: Little is known about the dose-response relationship between physical activity and health benefits among young people. Our objective was to analyse the association between the frequency of undertaking Moderate-to-Vigorous Physical Activity (MVPA) and the self-reported health status of the adolescent population.

Design: Cross-sectional study.

Setting: All regions of Spain.

Participants: Students aged 11-18 years participating in the Spanish Health Behaviour in School-aged Children (HBSC) survey 2006. A total of 375 schools and 21,188 students were selected.

Main outcomes: The frequency of undertaking MVPA was measured by questionnaire, as were the following four health indicators: self-rated health, health complaints, satisfaction with life, and health-related quality of life. Linear and logistic regression models were used to analyse the association, adjusting for potential confounding variables and the modelling of the dose-response relationship.

Results: As the frequency of MVPA increased, the association with health benefits was stronger. A linear trend ($p < 0.05$) was found for self-rated health and health complaints in males and females, and for satisfaction with life among females; for health-related quality of life, this relationship was quadratic for both sexes ($p < 0.05$). For self-reported health and health complaints, the effect was found to be of greater magnitude in males than in females and, in all scales, the benefits were observed from the lowest frequencies of MVPA, especially in males.

Conclusions: A protective effect of MVPA was found in both sexes for the four health indicators studied, and this activity had a gradient effect. Among males, health benefits

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3 were detected from very low levels of physical activity and the magnitude of the
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5 relationship was greater than that for females.
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For peer review only

Article summary

Article focus

- Although it is recommended that all adolescents should undertake 60 minutes of daily Moderate-to-Vigorous Physical Activity (MVPA), little is known about the nature of the relationship in this population, and whether or not the effect varies depending on age and sex.
- We examined cross-sectional associations between the frequency of undertaking self-reported MVPA and the health status of the adolescent population, using subjective health scales that are considered to be useful tools especially in the stage of adolescence, when psychological aspects are so important in the feeling of well-being among young people.

Key messages

- The protective effect of MVPA on health was detected from very low levels, below those established by current recommendations.
- A linear trend was found for self-rated health, health complaints and for satisfaction with life. For health-related quality of life the relationship was quadratic.
- The positive effect on health produced lower results in females than in males.

Strengths and limitations of this study

- The main strength is the representativeness and large size of the sample. The methodology employed is the standard one for the HBSC study in which more than 40 Western countries have participated.
- A major limitation is the cross-sectional nature of the study. Moreover, the measurement of health status using subjective health scales and the estimation of MVPA are both based on self-reported information.

INTRODUCTION

According to the World Health Organization (WHO)¹, physical inactivity is the fourth most important risk factor affecting global mortality, to which nearly 6% of all deaths are attributed. In the adolescent population, short-term benefits related to Physical Activity (PA) are improvements in lipid profile, blood pressure, metabolic syndrome, muscular strength and bone density, together with a reduction in obesity and overweight levels, as well as a decrease in emotional problems and depressive symptoms.²⁻⁵ Moreover, young people who undertake PA adopt healthy behaviour more easily and have better levels of academic achievement and cognitive functioning.^{4, 6-8}

The dose-response relationship between physical activity and various health indicators has mainly been studied in the adult population,⁹⁻¹⁵ where there is still a controversy about whether or not this relationship is linear.^{12,16} Ekelund et al.,¹⁷ in a pooled data analysis of 14 studies in children and adolescents, found a direct benefit between three tertiles of Moderate-to-Vigorous Physical Activity (MVPA) in relation to cardiometabolic outcomes. Although the WHO recommends that all children of 5-17 years of age take at least 60 minutes of daily MVPA,¹⁸ little is known about the nature of the relationship in this population. Therefore, finding out the effect on health of several levels of PA could have important implications for improving the recommendations regarding this activity.

It should be emphasized that concepts underlying health status in children and adolescents differ from those for adults. As young people are still developing, the measurement of health status must be approached from a global and comprehensive perspective for each individual. Concepts such as 'subjective health' and 'health-related quality of life' cover complex physical, emotional, mental and social aspects.^{19,20} Hence,

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3 it is important to evaluate if the effect of the PA is distributed in a distinct way for the
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5 different dimensions of health status.
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8 Finally, although PA varies considerably depending on age and sex,²¹ to our knowledge
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10 there have been very few studies in the literature about the role that these variables play
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12 regarding the effect of PA on health.⁴
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15 The objective of this study was to analyse the association between the frequency of
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17 undertaking MVPA and the different dimensions of adolescent health status, assessing if
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19 this relationship differs according to age and sex.
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22 23 24 25 **METHODS**

26 27 **Study population**

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30 The source of information was the Health Behaviour in School-aged Children (HBSC)
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32 study carried out in 2006.²² The population was a representative sample of
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34 preadolescents and adolescents, with an age range of 11-18 years, resident in Spain and
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36 enrolled in school from the 5th year of primary school to the last year of upper
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38 secondary school (2nd year of baccalaureate). A multistage stratified random sampling
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40 was used, taking into account age strata (4 groups), region (17 autonomous
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42 communities), school site (rural and urban), and type of school (public and private).
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44 Initially, 480 schools were contacted of which 377 (103 private and 274 public schools)
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46 agreed to participate in the study, which represented a response rate of 78.5%. **On**
47
48 **average, three classes were selected in each school.** A total of 22,350 questionnaires
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50 were collected, although subsequently 539 were excluded because of non-response to
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52 questions about sex and age, or lack of response to more than 50% of the questionnaire.
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57 The sample size was 21,811 participants. The study was carried out in spring 2006.
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3 Previously trained survey technicians visited the selected schools, where the students
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5 completed an anonymous questionnaire during normal school hours.
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8 This study was approved by the Institutional Review Board of the Carlos III Institute of
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10 Health .
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12 Study variables

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14 Health status was measured using four indicators: 1) self-rated health was measured using
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16 the question “*Would you say that your health is: excellent, good, fair or bad*”. Optimal
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18 health status was categorized by a response of excellent or good, and sub-optimal health
19
20 status was categorized by a response of fair or bad. 2) The health complaints indicator
21
22 was assessed using a scale based on the HBSC-Symptom Checklist, which is a list of
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24 eight physical and psychological symptoms (headaches, abdominal pain, backache,
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26 feeling low, irritability, nervousness, sleeping difficulties and dizziness), to estimate their
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28 frequency during the last six months. Having 2 or more symptoms with a frequency of
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30 several times a week or daily was considered to define having noticeable subjective
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32 health complaints.¹⁹ 3) Satisfaction with life was estimated using the Cantril Ladder,²³ in
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34 which, using a scale from 0 to 10, the participant was asked “*on which rung of the ladder*
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36 *(scale from 0 to 10) do you feel you stand at this moment in your life?*”, with 0 being the
37
38 worst score and 10 the best. A score of 0 to 5 was categorized as dissatisfied, whereas a
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40 score of 6 to 10 was categorized as satisfied.¹⁹ 4) Health-related quality of life was
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42 measured using the Kidscreen-10 index,²⁴ a series of 10 questions about mood, ability to
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44 concentrate, energy, vitality, well-being, ability to have fun with friends. Each question
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46 has five categories of response ranging from “never” to “always” or from “not at all” to
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48 “extremely often”. The items fulfil the assumptions of the Rasch model. To make the
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50 interpretation more applicable, the scores of the Rasch scales are translated into T-values
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with scale means of 50 and standard deviation of 10, with higher values indicating higher health-related quality of life.²⁴

The frequency of MVPA was measured using the question: “*in the last seven days, considering moderate and vigorous activity... On how many days did you feel you were physically active for a total of 60 minutes per day?*” The response categories were from 0 to 7 days. This question, when compared with PA assessed by accelerometers in Spanish adolescents, has shown an acceptable validation (Spearman correlation=0.43).²⁵

The following factors were considered as potentially confounding variables for the association between health status and frequency of MVPA: 1) personal variables (sex, age, country of birth, current smoker, alcohol consumption, body-mass index –calculated as the ratio of weight in kg/height in m² from self-reported weight and height, and defining overweight and obesity using the cut-off points proposed by Cole et al.,²⁶ consumption of fruit and vegetables, daily breakfast, number of hours each day spent watching television and using computers or game consoles, number of hours each day spent doing school homework); 2) family variables (employment status of the father, employment status of the mother, family purchasing power –measured by the Family Affluence Scale,²⁷ an index estimated by four items: number of times that the adolescents have been on holiday with their family in the last 12 months; does the family own a car or van; does the student have his/her own bedroom; number of computers owned by the family-, country of birth of the father, country of birth of the mother, type of household – both parents, single parent, blended family–, number of minors in the household, number of adults in the household); and 3) relationships with the school, the family and friends (academic achievement, satisfaction with family relationships, satisfaction with relationships with friends). The variables are categorized in Table 1.

Data analysis

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3 The questionnaires with missing values were excluded from data analysis, so that the
4 number of subjects studied was 17,467 for self-rated health; 17,358 for satisfaction with
5 life; 16,803 for health complaints; and 16,560 for health-related quality of life. The
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7 sample excluding missing values was similar to the original (there was no statistically
8 significant difference), comparing the main socioeconomic variables, health status, and
9 the frequency of undertaking MVPA.
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16 The complex sampling design was taken into account during analysis by using the
17 “Survey Data” module of the statistical package Stata v11. Standard errors were
18 computed by using the linearized variance estimator based on a first-order Taylor series.
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20 Prevalence was calculated for optimal self-rated health, low level of health complaints,
21 high satisfaction with life, and the means for the scores on the scale for health-related
22 quality of life, with 95% confidence intervals, both global and for the categories of each
23 one of the exposure variables.
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32 Regression models were used, logistic ones for the estimation of the odds ratio of
33 prevalence (OR) and linear ones for the calculation of the regression coefficients,
34 adjusting for the potential confounding variables mentioned above. All co-variables were
35 added simultaneously into the models. First, we calculated the association between the
36 frequency of undertaking MVPA and health status by estimating OR for the following
37 categories: 1-2 days, 3-4 days, 5-6 days, and 7 days, using ‘never’ as the reference.
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39 Second, linear and quadratic trends of the association between MVPA and the health
40 indicators were calculated from the regression models. For the linear trend, the average
41 value for each category was used modelling it as a continuous variable, while for the
42 quadratic trend the square of these values was used. Statistical significance was set at
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p<0.05.

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3 To further explore the relationships between MVPA and health status indicators without
4 imposing any particular functional form for the dose-response trends, the amount of
5 moderate-to-vigorous physical activity was entered in regression models using restricted
6 quadratic splines with knots at 1, 3.5, and 6 days/week.²⁸ Restricted quadratic splines
7 allow for different quadratic trends within each intermediate category and linear trends in
8 boundary categories, and hence they can accommodate a wide variety of smooth dose-
9 response curves, while avoiding implausible shapes at the tails of the exposure
10 distribution.
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21 Interactions between MVPA, age and sex were evaluated. Given that interactions were
22 found in the relationship between the frequency of MVPA and health status according to
23 sex, the results are shown separately for males and females.
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30 31 **RESULTS**

32
33 Table 1 describes the health status of the questionnaire respondents, as estimated by the
34 four health indicators. A total of 91.1% (CI 95%: 90.3-92.0) declared they had an
35 optimal self-rated health, 67.4% (CI 95%: 66.1-68.5) had a low level of health
36 complaints and 90.9% (CI 95%: 90.1-91.6) reported a high satisfaction with life. The
37 mean score on the scale for health-related quality of life was 47.1 (CI 95%: 46.5- 47.6).
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45 According to all the indicators used, the level of health was better, in a statistically
46 significant way, for the questionnaire respondents who indicated that they undertook
47 MVPA more frequently, with gradual increases depending on the categories of MVPA
48 (Table 1). **The rest of potentially confounding variables considered, were also associated**
49 **with self-rated health, less health complaints, high satisfaction with life and health-**
50 **related quality of life (Tables 1 and 2).**
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3 No statistically significant interactions were found between MVPA and age, whereas
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5 statistical significance was reached between MVPA and sex for the indicators self-rated
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7 health and satisfaction with life.
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10 Tables 3 and 4 and Figure 1 show the results of the multivariate analysis that evaluated, for
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12 each sex separately, the association of the frequency of undertaking MVPA with the
13
14 different indicators of health status, controlling the effect on this association of personal and
15
16 family factors. For both boys and girls, there was a positive, graded and statistically
17
18 significant association (linear trend, $p < 0.001$) between MVPA and self-rated health (Table
19
20 3), with odds ratios (OR) that ranged in males from 2.37, for those who undertook MVPA
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22 on 1-2 days, to 4.60 and 4.05, for those undertaking it on 5-6 and 7 days, respectively.
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24 Moving from less than 5 days to 5-6 days of MVPA, the OR increased from 2.34 to 4.60. In
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26 females, although a positive association was also found, the magnitude of the benefits on
27
28 self-reported health was lower, with values that were half those for the males (OR= 2.14, if
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30 MPVA undertaken 7 days).
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35 Regarding less health complaints (Table 3), an increase in the positive effects was seen in
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37 males from small amounts of MVPA on 1-2 days (OR=1.66, $p=0.008$), which increased
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39 further to an OR of nearly 2 for MVPA on 5-6 days. In females, this effect was lower,
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41 reaching statistical significance after MVPA on 5-6 days with an OR of 1.46 ($p=0.009$). The
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43 linear trend p-value was statistically significant ($p < 0.001$) in both males and females.
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46 The degree of satisfaction with life (Table 3) was also shown to be significantly associated
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48 with the frequency of undertaking MVPA; among the boys the OR for high satisfaction
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50 increased to 1.99 if physical activity was undertaken on 1-2 days per week, and satisfaction
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52 remained at these values for frequencies of more than 5 days of MVPA. In girls, the
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54 magnitude of the effect was similar, but the gradient was steeper. The linear trend p-value
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56 was statistically significant for females ($p < 0.001$), but not for males.
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3 Table 4 shows the same analysis applied to health-related quality of life, considering it
4 as a continuous variable and using linear regression to analyse it. In males, an increasing
5 dose-response effect was seen, especially noticeable after 5-days per week of MVPA
6 ($\beta=3.03$), which increased even further, to 5.08, for those undertaking MVPA for 7-days
7 per week. In females, the benefits were lower at low levels of frequency of MVPA, but
8 reached the same magnitude from 5 days of MVPA. Overall, this indicator was the one
9 that showed fewer differences between boys and girls, as can be seen in Figure 1. The
10 quadratic trend p-value was statistically significant in males ($p=0.006$) and females
11 ($p<0.001$).

22 23 24 25 26 **DISCUSSION**

27 28 **Principal findings**

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30 The results of this study clearly show the benefits of undertaking physical activity on the
31 health status of adolescents enrolled in schools in Spain. The following results should be
32 highlighted: 1) the magnitude of the effect, with benefits for optimal health reaching OR
33 higher than 4 for males who undertook MVPA daily or on most days, as compared to
34 those who never undertook it; 2) the existence of a dose-response effect, with the
35 positive effects increasing in accordance with the increase in the frequency of MVPA; 3)
36 the consistency of the results with the association present for the four health indicators in
37 both sexes; and 4) the greater positive effect in males, especially at low levels of
38 frequency of MVPA.

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40 Few studies have linked the effect of MPVA on general indicators of health status in
41 adolescents. Using data from the HBSC study for adolescents from North America,
42 Western Europe, Eastern Europe, Northern Europe and Southern Europe, Iannotti et al.²⁹
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3 evaluated the relationship between the frequency of PA and self-rated health, health
4 complaints and satisfaction with life and found, as in our study, beneficial effects for all
5 three indicators.
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9 10 **Dose-response relationship**

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12 The dose-response relationship between PA and health implies that increases in PA are
13 related with additional improvements in health status, even when it is not undertaken
14 very frequently. This has also been found in other studies regarding dyslipidemia, blood
15 pressure, overweight and obesity, metabolic syndrome and mental health.^{4,30-32} However,
16 to our knowledge, there are no comparable studies that measure the nature of the
17 relationship on general indicators of health status. Indeed, there is a controversy about
18 whether this relationship is linear or curvilinear, as some studies have found linear
19 patterns, whereas others have not,^{4,30-32} probably because the patterns can be different
20 depending upon the health effect that is being assessed. In our study, a curvilinear
21 relationship was found with a slight slowdown in the health benefits beyond 3-4 days of
22 MVPA in the following indicators: self-rated health; health complaints; and satisfaction
23 with life. In contrast, for health-related quality of life in both sexes, the benefits
24 increased from these intermediate levels of MVPA. These differences in the dose-
25 response relationship suggest that the effect varies depending upon the different
26 dimensions of health status to which the indicators are related. Although self-rated
27 health has been proposed as a measurement of the summary effect of multiple
28 dimensions of health, it is more closely related to the physical dimension rather than the
29 mental and social ones.³³ Similarly, the scale for health complaints is related to
30 symptoms with psychosomatic components very frequently associated with
31 adolescence.³⁴ Yet, the scale for the quality of life, besides including such physical and
32 mental dimensions, also incorporates family and social relationships, which could
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3 suggest that these additional dimensions may be involved in the achieving of greater
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5 health benefits with the maximum frequencies of MVPA.
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8 It should be stressed that the benefits to health status are obtained from low levels of
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10 **MVPA**, especially for boys. Similar results have been reported for self-rated health in a
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12 young adult population³⁵ and regarding blood pressure and dyslipidemia in
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14 adolescents.^{31,32} This could have important implications for the preventive
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16 recommendations, because (although 60 minutes of physical activity is currently
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18 recommended, if possible on a daily basis) the fact that positive results of a moderate
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20 magnitude can be achieved with very small amounts of MVPA **may** encourage the
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22 participation of the more sedentary people. Nevertheless, the maximum benefits were
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24 obtained according to public health recommendations, so the message should be: “even a
25
26 little is good; more is better”.³⁶
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30 **Gender differences**

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33 The results in health that are derived from undertaking MVPA are greater in males,
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35 especially in self-rated health and, to a lesser extent, in having less health complaints.
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37 According to our study, females need to undertake more days of MVPA to obtain
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39 similar health benefits. However, the effect on satisfaction with life and health-related
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41 quality of life was fairly similar in males and females. These differences suggest that the
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43 variation of the effect of MVPA according to sex could also be associated to different
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45 dimensions of health status. Previous reviews have clearly shown important differences
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47 between males and females in the quantity, intensity and type of physical activity, and
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49 that, in part, these distinctions could be explained by biological differences and those
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51 relating to sociocultural environment and body image.^{21,37} It would, therefore, be
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53 interesting for subsequent studies to undertake detailed research about this relationship.
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58 **Strengths and weaknesses**

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3 To aid correct interpretation of these data, several limitations should be mentioned. First,
4 the limitation in causal inference, stemming from the cross-sectional nature of the study,
5 would theoretically affect the temporality of the association. That is, people who have
6 health problems can have limitations in undertaking physical exercise. However, from
7 the data of the National Health Survey of 2006,³⁸ only 1.7% of adolescents between 16
8 and 19 years do not undertake the leisure time physical exercise that they would like to
9 take because of health problems, hence, this figure would not affect the results obtained.

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18 **Second, the measurement of health status, MVPA and several covariables of the study is**
19 **based on self-reported information. Although it is difficult to anticipate the magnitude**
20 **and direction of the bias induced by measurement error in self-reported physical activity**
21 **without validity or reproducibility substudies, some degree of attenuation in the**
22 **underlying trends would be expected if the misclassification of physical activity status**
23 **was nondifferential with respect to health outcomes. Nevertheless, the measurement of**
24 **health status using subjective health scales, as in this present study, has been validated in**
25 **previous studies,^{20,23,24,39,40} and such scales are considered to be useful tools especially in**
26 **the stage of adolescence, when psychological aspects are so important in the feeling of**
27 **well-being among young people. The variable used for estimating MVPA has been**
28 **previously validated in an adolescent population of Spain, obtaining an acceptable level**
29 **of validity when compared with measurement using accelerometers.²⁵ Other variables,**
30 **such as self-reported BMI or tobacco consumption, have also been validated in Spain, by**
31 **comparing them with objective measurements.^{41,42} Third, it has not been possible to**
32 **differentiate the effect of the intensity of physical activity, which is a dimension**
33 **independently related with self-rated health.³⁵**

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The main strengths of this study are the representativeness and large size of the sample used, which means that the results can be extrapolated accurately, and that the

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3 methodology employed is the standard one for the HBSC study. This is a collaborative
4 WHO study in which more than 40 Western countries (including Spain) have
5 participated.
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9 10 **CONCLUSIONS**

11
12 To sum up, an association was found between the frequency of undertaking self-reported
13 MVPA and the health status of adolescents enrolled in schools in Spain. A linear trend
14 was found for self-rated health, health complaints and for satisfaction with life. For
15 health-related quality of life the relationship was quadratic. The benefits of MVPA on
16 health were detected from very low levels, below those established by current
17 recommendations. In general, the magnitude of association was lower in females than in
18 males, a finding that needs to be explained by subsequent research.
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32 generous contribution to this study.
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37 PR, FR and CM coordinated the field work and collected the data. IG, RB, MM and RP
38 conducted the analyses. IG and RB prepared the first draft. All authors contributed to the
39 interpretation of data and revision of the manuscript. All authors approved the final
40 version.
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54 **Competing interests:** None.
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3 **Ethics approval:** This study was approved by the Institutional Review Board of the
4
5 Carlos III Institute of Health.
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7
8 **Provenance and peer review:** Not commissioned; externally peer reviewed.
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10 **Data sharing statement:** Full results of the Spanish HBSC study are available at
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12 <http://www.msps.es/profesionales/saludPublica/prevPromocion/promocion/saludJovenes>
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14 [/estudioHBSC/nacional_hbsc.htm](http://www.msps.es/profesionales/saludPublica/prevPromocion/promocion/saludJovenes)
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Table 1. Description of the sample and distribution of optimal self-rated health, less health complaints, high satisfaction with life and health-related quality of life, according to individual variables. Spanish adolescents aged 11–18 years, 2006.

		Optimal Self-reported health N (17467)	Less health complaints N (16803)	High satisfaction with life N (17358)	Health-related quality of life N (16560)
		%	%	%	Mean
MVPA	Global	91.1	67.4	90.9	47.1
	Never	80.1*	54.1*	82.3*	42.6*
	1-2 days	87.5	62.8	87.4	44.3
	3-4 days	90.8	66.3	91.3	46.2
	5-6 days	94.8	72.8	93.1	48.2
Sex	7 days	95.9	74.1	95.2	52.5
	Men	93.3*	76.7*	91.9*	48.3*
Age	Women	89.3	59.5	90.0	46.1
	10-12	95.8*	68.6	94.9*	52.5*
	13-16	90.1	67.6	89.8	45.6
Born in Spain	17-18	86.8	65.1	87.7	43.2
	Yes	91.1	67.7*	91.2*	47.2
	No	91.2	62.9	85.3	45.7
Smoking	Non-smoker	94.5*	70.6*	94.0*	49.3*
	Smoker	80.9	56.6	83.7	42.8
	Ex-smoker	89.2	66.6	86.9	44.1
Consumption of alcohol	Never	95.4*	70.4*	94.3*	50.7*
	Rarely	89.9	65.2	88.9	45.4
	Monthly	88.1	66.3	87.2	43.5
	Weekly or daily	85.2	64.2	87.9	43.9
Body-mass index	Normal or underweight	92.5*	68.2*	91.5*	47.0
	Overweight	86.7	67.6	90.3	47.1
	Obese	77.4	58.0	83.0	46.6
	NR	90.4	64.6	89.4	47.2
Consumption of fruit and vegetables	Quartile 1	88.2*	64.1*	88.8*	45.8*
	Quartile 2	91.5	67.5	91.5	46.5
	Quartile 3	92.5	69.7	92.2	47.2
	Quartile 4	92.6	68.5	91.2	48.7
Breakfast during the week	Every day	93.2*	70.4*	92.6*	48.1*
	Not every day	85.5	59.1	86.1	44.3
Time spent TV and computers	Quartile 1	91.1	68.7*	91.5*	48.0*
	Quartile 2	91.1	69.4	91.8	47.0
	Quartile 3	91.7	68.8	91.5	47.0
	Quartile 4	90.2	62.8	88.7	46.2
	NR	92.6	65.4	89.3	48.6
Time spent studying/ homework	Quartile 1	89.3*	68.8*	87.1*	46.3*
	Quartile 2	92.2	69.3	91.9	47.9
	Quartile 3	92.4	68.8	92.5	47.7
	Quartile 4	90.5	62.9	91.5	46.3
	NR	89.4	69.3	88.6	48.4
Academic achievement	Very good	96.3*	71.8*	96.4*	52.4*
	Good	94.0	69.7	94.2	48.2
	Average	87.4	65.3	87.3	44.2
	Low	79.7	54.0	75.3	41.7

* p<0.05

MVPA: Moderate-to-Vigorous Physical Activity

NR: Non-response

Table 2. Description of the sample and distribution of optimal self-rated health, less health complaints, high satisfaction with life and health-related quality of life, according to family variables. Spanish adolescents aged 11–18 years, 2006.

	Optimal Self-reported health N (17467)	Less health complaints N (16803)	High satisfaction with life N (17358)	Health-related quality of life N (16560)
	%	%	%	Mean
Employment situation of father				
Paid employment	91.5*	67.8*	91.3*	47.2*
No paid employment	86.9	63.0	85.4	45.4
Don't know	90.3	52.9	91.5	43.3
No father	85.4	59.8	82.0	44.3
Employment situation of mother				
Paid employment	91.0	67.1	90.8*	47.1*
No paid employment	91.5	68.3	91.4	47.0
Don't know	90.9	59.1	91.4	47.5
No mother	83.7	58.7	78.0	45.2
Socioeconomic status				
Low	86.2*	62.6*	84.5*	45.2*
Average	91.2	66.7	90.9	46.9
High	92.9	69.9	93.2	48.0
Country of birth of father				
Spain	91.1	67.6	91.2*	47.1
Other countries	91.1	64.7	86.2	46.4
Country of birth of mother				
Spain	91.1	67.7*	91.1*	47.1
Other countries	91.9	62.4	87.3	46.1
Type of household				
Both parents	92.0*	68.4*	91.9*	47.3*
Single parent	86.9	62.2	85.0	45.7
Blended	83.0	59.3	82.6	44.2
Others	85.3	61.3	86.8	46.8
Number of adults in the household				
2	91.7*	64.1*	91.2*	47.3
0,1,3,4,5	88.8	68.3	89.3	46.4
Number of minors in the household				
1,2,3	91.1	60.3*	91.0	47.1
>3	90.6	68.0	88.8	46.8
Satisfaction: family relationships ^a				
Good	93.0*	45.2*	94.2*	48.0*
Fair-bad	75.9	70.1	64.2	39.4
Satisfaction: relationships with friends ^a				
Good	92.0*	48.5*	92.3*	47.5*
Fair-bad	77.1	68.6	68.5	40.0

* $p < 0.05$

^a Good: score 7-10; Fair-bad: score 0-6

Table 3. Logistic models. Association between the amount of moderate-to-vigorous physical activity and optimal self-rated health, less health complaints and high satisfaction with life. Spanish adolescents aged 11–18 years, 2006.

	Men		Women		
	OR* (95% CI)	P	OR* (95% CI)	P	
Optimal self-rated health					
Frequency of undertaking MVPA					
Never	1 (ref)		1 (ref)		
1-2 days	2.37 (1.56 to 3.58)	<0.001	1.20 (0.85 to 1.69)		0.282
3-4 days	2.34 (1.44 to 3.81)	0.001	1.51 (1.06 to 2.14)		0.020
5-6 days	4.60 (2.60 to 8.13)	<0.001	2.28 (1.47 to 3.52)		<0.001
7 days	4.05 (2.38 to 6.89)	<0.001	2.14 (1.37 to 3.34)		0.001
Linear trend P-value	<0.001		<0.001		
Quadratic trend P-value	0.325		0.850		
Less health complaints					
Frequency of undertaking MVPA					
Never	1 (ref)		1 (ref)		
1-2 days	1.66 (1.14 to 2.42)	0.008	1.16 (0.90 to 1.49)		0.226
3-4 days	1.65 (1.14 to 2.39)	0.007	1.21 (0.93 to 1.58)		0.143
5-6 days	2.09 (1.47 to 2.96)	<0.001	1.46 (1.10 to 1.93)		0.009
7 days	1.94 (1.38 to 2.73)	<0.001	1.32 (0.97 to 1.80)		0.076
Linear trend P-value	0.001		0.021		
Quadratic trend P-value	0.216		0.463		
High satisfaction with life					
Frequency of undertaking MVPA					
Never	1 (ref)		1 (ref)		
1-2 days	1.99 (1.20 to 3.31)	0.007	0.93 (0.63 to 1.36)		0.722
3-4 days	1.52 (0.90 to 2.55)	0.111	1.44 (0.99 to 2.10)		0.056
5-6 days	2.02 (1.17 to 3.49)	0.011	1.56 (0.98 to 2.49)		0.059
7 days	1.94 (1.09 to 3.44)	0.023	2.00 (1.19 to 3.35)		0.008
Linear trend P-value	0.128		<0.001		
Quadratic trend P-value	0.661		0.975		

* Adjusted for age, country of birth, smoking, alcohol consumption, BMI, consumption of fruit and vegetables, daily breakfast, time spent watching TV using computers, time spent studying, academic achievement, employment situation of the father and mother, socioeconomic status, country of birth of the father and mother, type of household, number of adults and number of minors in the household, satisfaction with family relationships and with friends.

Table 4. Linear models. Association between the amount of moderate-to-vigorous physical activity and health-related quality of life. Spanish adolescents aged 11–18 years, 2006.

	Men		Women	
	β * (95% CI)	P	β * (95% CI)	P
Frequency of undertaking MVPA				
Never	0 (ref)		0 (ref)	
1-2 days	1.61 (0.29 to 2.93)	0.017	0.19 (- 0.71 to 1.10)	0.676
3-4 days	1.87 (0.50 to 3.24)	0.007	1.19 (0.37 to 2.02)	0.005
5-6 days	3.03 (1.74 to 4.31)	<0.001	2.79 (1.76 to 3.82)	<0.001
7 days	5.08 (3.73 to 6.43)	<0.001	5.09 (3.86 to 6.32)	<0.001
Linear trend P-value	<0.001		<0.001	
Quadratic trend P-value	0.006		<0.001	

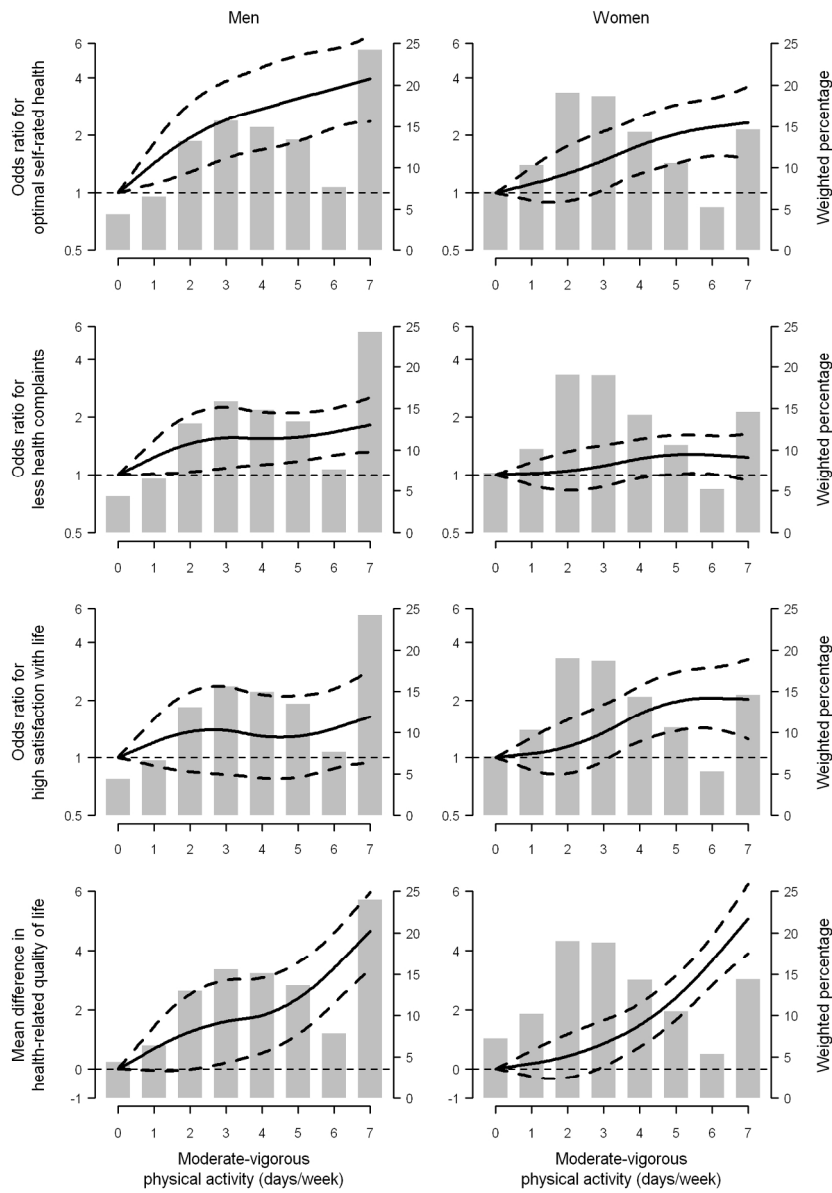
* Adjusted for age, country of birth, smoking, alcohol consumption, BMI, consumption of fruit and vegetables, daily breakfast, time spent watching TV and using computers, time spent studying, academic achievement, employment situation of the father and mother, socioeconomic status, country of birth of the father and mother, type of household, number of adults and number of minors in the household, satisfaction with family relationships and with friends.

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3 Figure 1. Dose-response relationship of the amount of self-reported Moderate-to-
4 Vigorous Physical Activity (MVPA) with optimal self-rated health, less health
5 complaints, high satisfaction with life, and health-related quality of life among Spanish
6 adolescents aged 11–18 years.
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11 *Footnote:*

12 Curves represent adjusted odds ratios or mean differences (solid lines) and their 95%
13 confidence intervals (dashed lines) based on restricted quadratic splines for the amount
14 of MVPA with knots at 1, 3.5, and 6 days/week. The reference value (odds ratio = 1 and
15 mean difference = 0) was set at 0 days/week of moderate-vigorous physical activity.
16 Odds ratios and mean differences were obtained from logistic and linear regression
17 models accounting for the complex survey and adjusted for personal and familial risk
18 factors (see Methods). Bars represent the weighted bar charts of the amount of MVPA
19 among men and women.
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