TITLE: Effects of adolescent sport practice on health outcomes of adult amateur endurance cyclists: adulthood is not too late to start

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Abstract:

Background: We investigated the effects of adolescent sport practice on the training, performance, and health outcomes of adult amateur endurance cyclists and compared health outcomes of 3 adult groups: amateur endurance cyclists who practiced sports during adolescence, amateur endurance cyclists who did not practice sports during adolescence, and inactive individuals. **Methods:** In 859 (751 men, 108 women) adult cyclists and 718 inactive subjects (307 men, 411 women), we examined adolescent sport practice, current training status, quality of life, quality of sleep, anxiety and depression and cardiometabolic risk: body mass index, physical activity, physical fitness, adherence to Mediterranean diet, and alcohol and tobacco consumption. **Results:** Independent of gender, no significant differences in training, performance, or health outcomes were observed between amateur endurance cyclists who practiced sports during adolescence and those who did not. Male and female cyclists reported significantly better health outcomes than inactive control men and women, respectively, in all variables, except depression for men, and depression and alcohol consumption for women. **Conclusions:** training, performance, and health outcomes did not differ between adult amateur endurance cyclists who practiced sports during adolescence and those who did not, but their health outcomes were significantly improved compared to inactive individuals, except for depression.

KEYWORDS: exercise, physical activity, physical performance

INTRODUCTION

Regular exercise is associated with risk reductions in multiple chronic diseases and all-cause mortality[1], and sedentary behavior has been described as a major public health problem of the 21st century[2], with an increasing prevalence worldwide. Only 61% of the adult European population[3] performs physical activity at levels sufficient to achieve the World Health Organization recommendations. However, an increasing number of amateur athletes and cyclists participate in endurance exercise events. In fact, the number of individuals performing endurance exercise events has tripled in the last 2 decades[4]. Amateur cycling is one of the most common sport/exercise activities, and its practice has been associated with a significant reduction in all-cause mortality (Oja et al 2016) and cardiometabolic risk, as well as with an improvement in physical quality of life, and increase in exercise addiction risk (Mayolas et al 2017).

Sports performed during adolescence have been associated with improvements in psychosocial health[5], obesity[6], fitness[7], health-related quality of life[8], sleep[9], diet[10], and alcohol and tobacco consumption[11] and may predict improved health and behaviors in adulthood[12]; they therefore play a relevant role in the prevention of chronic diseases[13–16]. Although there is sufficient scientific literature to support this notion in samples of the general population with heterogeneous levels of adult physical activity, no studies have analyzed the effects of sport practice during adolescence on the training, performance, and health outcomes of amateur athletes performing intense training regimens during adulthood. It is unknown whether commencing structured training in adulthood in previously inactive individuals is sufficient or whether it is too late to induce the optimal beneficial adaptations in health outcomes obtained by those who commenced sports during adolescence.

The present study was conducted to evaluate the effects of adolescent sport practice on the training, performance, and health outcomes of adult amateur endurance cyclists and to compare the health outcomes between 3 groups of adult subjects: 1) amateur endurance cyclists who practiced sports during adolescence, 2) amateur endurance cyclists who did not practice sports during adolescence, and 3) inactive individuals. We hypothesized that early sport practice is not related to the training, performance, and health outcomes of adult amateur cyclists and that adult amateur cyclists would report better health outcomes than inactive control subjects.

METHODS

Procedures and Participants

An invitation to participate in the study was sent via e-mail to the representatives of the 3,426 cycling clubs that were integrated into the Royal Spanish Cycling Federation in 2016. The invitation included a brief introduction to the study, an explanation of the anonymous and voluntary nature of participation in the study, a link to the online survey, and a request for the information to be distributed to the 62,856 male and 2,483 female amateur cyclists officially registered in Spain. In total, 1023 potentially eligible cyclists responded and sought more information about the study. Amateur cyclists included in this study had histories of intensive cycling practice, meeting the following criteria: a volume of endurance training higher than 7 hours per week, experience of at least one year of training to participate in cycling events, and intention to participate in road cycling events (> 100 km) or mountain bike events (> 45 km). Data were collected in May of 2016 and processed in June of 2016. Finally, 859 amateur cyclists (751 men, 108 women) were recruited. A total of 164 cyclists were excluded from the study for not meeting these criteria. Each cyclist was instructed to invite inactive subjects who had similar sociodemographic characteristics to participate in the study. Of a total of 1527 subjects, 718 age-controlled subjects (307 men and 411 women) were classified as inactive based on the short version of the International Physical Activity Questionnaire[17] and were included as the control group. The participants answered an online survey with questions regarding age, gender, height, and weight and answered the questionnaires described below, which included questions about sociodemographic status, training, athletic performance and health status. There was no time limit to completing the questionnaires. The questionnaires took an average of 40 min to complete, and the internet design prevented missing data. The cyclists were classified into 2 groups: those who practiced sports during adolescence and those who did not practice sports during adolescence. The data collection was completed on the last week of May. The participants gave their informed consent for the scientific use of the data. The research complied with the Spanish law of data protection and the Declaration of Helsinki and was approved by the Committee on Biomedical Ethics of the Aragon Government.

Measures

Sport practice during adolescence

Physical activity performed in adolescence was assessed through a question used in previous studies[14,16]: ‘‘Outside school, were you engaged in any organized/supervised sport activities in clubs for at least 1 year from 11 to 17 years of age?’’ Other physical activities such as different dance modalities were also included.

Sociodemographic status

In addition to sex and age, a questionnaire was designed to evaluate the main sociodemographic variables that may condition the balance of training with family, social, and work obligations: size of municipality of residence, education level, marital status, number of children, type of occupation, and income level.

Training, athletic performance and distance cycling events

A questionnaire was designed to evaluate the training volume (hours per week in the last month), frequency (days per week in the last month) and experience (years participating in amateur endurance cycling events) of cyclists. The average speed of 100 road cyclists (83 men and 17 women) who participated in the same cycling event (198 km and 3,500 m of positive slope) was recorded. This analysis was also performed in 60 male mountain bike cyclists (163 km and 4,700 m positive slope).

Health status

Quality of life

Version 2 of the Short-Form 12-Item Health Survey questionnaire was used to assess health-related quality of life because it has shown good psychometric properties[18]. Self-reported quality of life has been found to be a good predictor of illness and wellbeing. This survey consists of 12 questions related to 8 sub-scales divided into 2 summary components: physical and mental health. Higher scores indicate better functioning.

Quality of sleep

Quality of sleep was evaluated with the Pittsburgh Sleep Quality Index[19], which has shown satisfactory psychometric properties. This questionnaire consists of 19 self-rated questions combined into 7 components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleeping medications and daytime dysfunction. These component scores are then summed to yield a global score, ranging from 0 to 21, with higher scores indicating worse sleep quality.

Psychological symptoms: depression and anxiety

We used the Hospital Anxiety and Depression Scale[20] to determine the levels of anxiety and depression, which has shown satisfactory psychometric properties[21]. This questionnaire consists of 7 items related to anxiety and 7 items related to depression. Each item on the questionnaire is scored from 0–3, indicating that a person can score between 0 and 21 for either anxiety or depression. Higher scores represent higher symptom levels.

Behavioral cardiometabolic risk factors

Based on the World Health Organization criteria[22], we established physical inactivity, unhealthy diet and tobacco and alcohol consumption as behavioral cardiometabolic risk factors. These factors are associated with the main causes of morbidity and mortality[23]. Additionally, we measured body mass index and physical fitness. Body mass index was calculated based on self-reported values of weight and height. The level of physical activity was established by the short version of the International Physical Activity Questionnaire[17], which has shown acceptable measurement properties. This questionnaire classifies subjects as having low, moderate or vigorous physical activity levels. We evaluated cardiorespiratory fitness, muscular fitness, speed-agility, flexibility and overall fitness using the international fitness scale[24]. This instrument stratifies subjects according to their level of physical fitness and predicts the risk of cardiovascular disease. We used a 14-point Mediterranean Diet Adherence Screener[25] that has been shown to be a valid instrument to evaluate adherence to the Mediterranean diet. Consumption of and dependence on tobacco was evaluated by the Fagerström Test for Nicotine Dependence Revised[26], which has shown good psychometric properties. Alcohol consumption per week was assessed by the sum of products, which was calculated by multiplying the frequency of consumption of beer, wine and spirits by standard alcohol units, in which a standard alcohol unit was equivalent to 10 g of pure alcohol[27].

Statistical analysis

The statistical analyses were performed using IBM Statistical Package for the Social Sciences (IBM SPSS Statistics, v. 20.0 for WINDOWS) software. The data are presented as the mean ± standard deviation unless otherwise stated. Kolmogorov-Smirnov tests were used to check for the normality of distributions, and the data were then log-transformed prior to testing for significant differences between groups. To measure the differences in the variables of interest between the groups of cyclists (who practiced sports during adolescence and those who did not practice sports during adolescence) and the control group, we used analysis of variance test. Bonferroni correction was used to adjust the calculated *p* values to prevent type I error caused by the multiple comparisons. We also performed 2-way analysis of variance to establish whether there was an interaction of gender in health outcomes. The values were considered to be significant at $p < 0.05$.

RESULTS

Women represented 14.4% (n=108) and 57.2% (n=411) of the cyclists and inactive control group, respectively. Independent of gender, no significant differences in training or competition performance variables were observed between amateur endurance cyclists who practiced sports during adolescence and those who did not (Table 1).

Table 2 shows the health status outcomes of each group stratified by gender. No significant differences in age were observed between any groups. No significant differences were observed in any variable between amateur endurance cyclists who practiced sports during adolescence and those who did not. Male cyclists reported significantly better health outcomes than inactive control men in all variables, except for depression, in which inactive control men reported significantly better scores. Female cyclists also reported significantly better health outcomes than inactive control women in all variables, except for depression and alcohol consumption.

DISCUSION

The main finding of the present study is that inactive control participants showed significantly worse health outcomes than amateur endurance cyclists, but cyclists who started practicing sports after adolescence did not have different health outcomes than those who started adolescence. Despite their high interest for public health, these findings have not been previously demonstrated. These results are in line with a recent and pioneer study showing that persons with persistently low ideal cardiovascular health status (physically active, not smoking, healthy diet, and normal body mass index, blood pressure, glucose, and cholesterol) are at an increased risk of cardiometabolic outcomes; however, persons who have improved their ideal cardiovascular health status from low to high did not have a different risk of cardiometabolic outcomes than participants who always had a high ideal cardiovascular health status[28]. Different studies have shown that healthy and unhealthy lifestyle changes during young adulthood are associated with decreased and increased risks, respectively, of cardiometabolic outcomes in middle age[29–31].

Cardiometabolic and health outcomes in middle age seem to be reversible among individuals who become amateur endurance cyclists during adulthood. The effects of high volume endurance training during adulthood appear to be powerful enough to induce short-term beneficial adaptations in health outcomes that match those observed in amateur endurance cyclists who started training during adolescence. The lack of differences in health outcomes between cyclists who began practicing sports during and after adolescence can be explained by human's adaptation abilities. Furthermore, cycling appears to be more beneficial among inactive people for ACM and CVD (data available on request)[32]. Several studies on physical activity intervention programs in children have shown that the positive intervention effects obtained could not be sustained after the intervention with increasing follow-up times[33,34]. These findings are clinically important because they emphasize the importance of maintaining physical activity during adulthood and because physical activity is significantly related to other healthy behaviors[10].

Most studies that have analyzed the effects of early sport practice on adult health showed improvements in individuals who practiced sports during adolescence[13,15,16,35]; however, these studies recruited adult samples who were attempting to achieve the minimum physical activity level recommendations for health-promoting effects, with heterogeneous levels of physical activity. Our amateur endurance cyclists did not show differences between those who commenced sports during and after adolescence, probably due to the high and homogeneous volume of training performed during adulthood. If our participants practiced a lower volume of training, we would likely identify differences, as observed in previous studies[13,14,16,35]. Our study is the first to analyze the effects of early sport practice in amateur athletes with a high volume of training; consequently, further studies are needed to identify the quantity and quality of exercise required during adulthood for inactive adolescents to obtain the same health benefits as individuals engaged in sports during adolescence.

The identified improvements in health outcomes in the cyclists with respect to inactive controls can be explained by the positive effects of endurance training on health status[36] and by the fact that high volumes of endurance training improve cardiovascular risk factors[37]. Currently, it is unknown whether greater health benefits are obtained at higher exercise volumes[38]. Our results provide evidence that in both genders, the practice of amateur endurance cycling induces an overall better health profile than that observed in healthy inactive individuals. Our findings are broadly consistent with those of other studies conducted in adult populations, which have shown positive effects of physical exercise on health-related quality of life, physical fitness[39], anxiety[40], sleep[41], body composition[42], diet[43], and tobacco and alcohol consumption[11].

Male cyclists showed higher scores for depressive symptoms than inactive controls, but both values were in a non-clinical range on average. The reasons for these high depressive symptoms in endurance cyclists are not fully clear. They may be partly attributable to the individual nature of cycling and the overlap of the assessment with the in-season period of maximum volume of training (May). Participation in team sports has been shown to be associated with lower depression scores than participation in individual sports[44,45], and some studies have shown that high volume phases of training are concomitant with alterations in mood state[46]. The absence of significant differences in alcohol consumption between cyclists and inactive women could be due to the low alcohol consumption of women and the small sample of female cyclists. Different studies have confirmed lower alcohol consumption in women than in men[47].

The present study has several limitations. The cross-sectional and retrospective design of our study precludes the identification of any causal relations. However, our study is the first to compare amateur endurance athletes who commenced training at different ages. Further longitudinal studies with cyclists and other athletes are needed to support or reject these initial findings and to extrapolate these findings to other training modalities. Our relatively small sample of female cyclists also limits the statistical power and validity of the data. An improved control of gender and ethnicity should be focused on in future research. Another limitation is the lack of data regarding the type, years of participation, intensity and frequency of sport activities performed during adolescence. Future studies that analyze the influence of the type and dose-response of physical exercise performed during adolescence on the health outcomes and prevention of diseases in adulthood are needed. As with all research based on self-reported measures, there are also inherent limitations to these data, such as recall bias and social desirability, that should be taken into account when interpreting our findings. However, well-established, valid, and reliable measures of health that apply norm-based scoring methodology were used. Future research initiatives should quantify body composition, sleep, physical activity, physical fitness levels, and other health outcomes using objective methods.

In conclusion, this study demonstrated that the training, performance, and health outcomes did not differ between adult amateur endurance cyclists who practiced sports during adolescence and those who did not but that their health outcomes were significantly improved compared to inactive individuals, except for depression. Amateur endurance cycling is a recommended practice because it is a form of leisure-time physical activity for adults that can produce a wide range of health benefits. Health care policies should focus on improving or maintaining health behaviors such as being physically active during adulthood to prevent a number of chronic diseases.

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Tables

Table 1

Comparison between amateur cyclists who practiced sport during adolescence and those who did not.

	Men			**Women**		
	Cyclists who practiced sport during adolescence (n=379)	**Cyclists who did not practice sport during adolescence (n=372)**	***p* value**	**Cyclists who practiced sport during adolescence (n=45)**	**Cyclists who did not practice sport during adolescence (n=63)**	***p* value**
Training						
Frequency last month (days/week)	3.8 ± 1.3	3.8 ± 1.3	0.579	3.7 ± 1.5	3.6 ± 1.5	0.649
Volume last month (hours/week)	11.2 ± 4.7	11.0 ± 4.5	0.526	9.9 ± 3.7	10.5 ± 4.7	0.439
Experience in cycling events (years)	4.6 ± 4.7	4.5 ± 4.8	0.761	3.0 ± 2.6	3.0 ± 3.1	0.996
Competition performance						
Road cycling (km/h)	26.6 ± 4.1	26.3 ± 4.2	0.794	27.2 ± 7.3	23.4 ± 2.8	0.221
Mountain biking (km/h)	14.3 ± 2.2	14.9 ± 3.2	0.438	-	-	-

Values are the mean ± SD or percentage. The analysis of competition performance was conducted for road cycling in a sample of 83 men (Cyclists who commenced training during adolescence:: n=47; Cyclists who commenced training after adolescence:: n=36) and 17 women (Cyclists who commenced training during adolescence:: n=10; Cyclists who commenced training after adolescence:: n=7) who participated in the same event (198 km, 3,500 m positive slope). This analysis was performed for mountain biking in a sample of 60 male cyclists (Cyclists who commenced training during adolescence: n=27; Cyclists who commenced training after adolescence: n=33) who participated in a 163 km event with a 4,700 m positive slope.

Table 2

Comparison among inactive individuals, cyclists who practiced sport during adolescence, and those who did not.

	Men			Women		
	Cyclists who practiced sport during adolescence (n=379)	**Cyclists who did not practice sport during adolescence (n=372)**	**Inactive control group (n=307)**	**Cyclists who practiced sport during adolescence (n=45)**	**Cyclists who did not practice sport during adolescence (n=63)**	**Inactive control group (n=411)**
Physical QoL (0-100)	56.5 ± 5.5	56.2 ± 5.9	51.8 ± 8.5* #	56.0 ± 6.5	56.4 ± 5.3	51.1 ± 10.6* #
Mental QoL (0-100)	50.2 ± 10.5	49.7 ± 10.7	43.2 ± 15.4* #	49.8 ± 12.8	48.1 ± 11.6	39.4 ± 17.3* #
Sleep (0-21)	4.6 ± 2.6	4.4 ± 2.4	5.2 ± 2.8* #	3.9 ± 2.0	4.6 ± 2.8	5.2 ± 3.1*
Anxiety (0-21)	8.0 ± 1.9	8.0 ± 1.9	9.2 ± 2.3* #	7.8 ± 1.8	7.9 ± 1.6	9.3 ± 2.4* #
Depression (0-21)	9.8 ± 1.5	9.9 ± 1.6	9.3 ± 1.9* #	10.0 ± 1.9	9.7 ± 1.5	9.5 ± 1.9
Cardiometabolic risk						
Age (years)	38.3 ± 8.9	38.1 ± 8.1	38.2 ± 12.0	37.3 ± 7.1	38.8 ± 8.0	37.8 ± 11.2
BMI (kg/m^2)	24.2 ± 2.5	24.5 ± 2.7	26.3 ± 4.5* #	22.1 ± 3.2	22.1 ± 2.5	24.0 ± 4.2* #
PA (MET-min wk)	7050 ± 4213	7083 ± 3898	1064 ± 905* #	6397 ± 4316	6071 ± 3666	924 ± 750* #
PC (1-5)	3.8 ± 0.6	3.7 ± 0.5	2.8 ± 0.6* #	3.9 ± 0.7	3.8 ± 0.6	2.7 ± 0.7* #
AMD (0-14)	8.3 ± 2.0	8.3 ± 2.1	7.1 ± 2.0* #	8.7 ± 2.0	9.3 ± 1.9	7.8 ± 1.9* #
Tobacco (0-16)	0.3 ± 1.3	0.2 ± 0.9	1.8 ± 3.1* #	0.0 ± 0.2	0.0 ± 0.0	0.9 ± 2.2* #
Alcohol (SAU per week)	5.8 ± 6.8	6.0 ± 8.8	8.3 ± 9.5* #	1.7 ± 3.1	2.3 ± 5.1	3.2 ± 4.7

Values are the mean ± SD. QoL: Quality of Life; BMI: Body Mass Index; PA: Physical Activity; PC: Physical Condition; AMD: Adherence to the Mediterranean diet; SAU: Standard Alcohol Units.

* $p<0.05$ significantly different from cyclists who practiced sport during adolescence; # $p<0.05$ significantly different from cyclists who did not practice sport during adolescence.