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PHYSICAL ACTIVITY IN ADOLESCENCE AND TESTICULAR GERM CELL CANCER RISK

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Abstract

Objective—Several, but not all, studies have observed increased risks of testicular germ cell cancer (TGCC) associated with bicycling and other recreational activities. To further examine whether physical activity (PA) in adolescence is associated with TGCC risk, the authors conducted a case-control study in western Washington State.

Methods—Cases (n=391) were men diagnosed with TGCC who were identified through a population-based cancer registry. Controls (n=1023) were men identified from the general population in western Washington State by using random digit telephone dialing. Participants were queried about various specific PA in grades 7–12 including bicycling, horseback riding, competitive sports, physical education class, as well as moderate, vigorous, and sedentary activities in general.

Results—In multivariate analyses, bicycling, vigorous-intensity activities, and sedentary activities were not associated with TGCC risk, while horseback riding and wrestling were associated with decreased risks, and moderate-intensity activities, soccer, basketball and intermediate duration of competitive activities were associated with increased risks.

Conclusions—The lack of internal consistency of the findings within the current study and of findings among prior studies, suggests that PA contributes little, if any, to the risk of TGCC.

Keywords

testicular cancer; physical activity; case-control study; adolescent

INTRODUCTION

Testicular germ cell carcinoma (TGCC) is the most common malignancy in younger men. Age, history of undescended testes, family history of testicular cancer, and race/ethnicity are the only established risk factors for the disease (1). Although not entirely consistent, associations observed for inguinal hernia, estrogen excess during gestation, maximal height attained, and the relatively young age at which testicular cancers are diagnosed compared to other cancers suggest that early life events are involved in testicular cancer carcinogenesis (2,3). Because the incidence rises sharply after puberty, gonadotropic and androgenic hormones, including testosterone, are thought to stimulate the growth and progression of these malignancies. Physical activity (PA) has both acute and chronic effects on hormone levels (4) and thus could plausibly influence TGCC risk. Testicular atrophy and injury are also mechanisms thought to

be involved in TGCC initiation or progression. PA such as horseback riding and bicycling have been suspected as possible causes of clinical or subclinical testicular trauma or injury; prior studies have investigated associations of these activities with TGCC risk (5–7). Coldman and colleagues observed an increased risk for riding activities (6), and several subsequent studies produced similar findings (5,7). In a fourth study, relatively high levels of PA in adolescence were associated with increased TGCC risk (8), but this result was not replicated in several other studies (9–13). The inconsistent results may be due in part to small sample sizes as well as to measurement error of PA in terms of type, frequency, duration, and timing. Thus, the aim of the current study was to examine associations of TGCC risk and type, duration, frequency and total amount of recreational PA during adolescence.

MATERIAL AND METHODS

We conducted a population-based case-control study in Western Washington State. Potentially eligible cases were identified through the Cancer Surveillance System, a part of the Surveillance, Epidemiology and End Results Program of the National Cancer Institute (14). All 18–44 year-old male residents of King, Pierce and Snohomish Counties, Washington State, diagnosed with an invasive TGCC (International Classifications of Diseases–Oncology topography codes C62.0–C62.9 and histology codes 9060–9091 (14)) between January 1, 1999 and May 31, 2006, were eligible to participate if they were capable of communicating in English and had a landline residential telephone (because controls were ascertained through random-digit dialing (RDD) of landline residential telephone numbers). After identifying a potentially eligible case, we first contacted his physician to determine whether there was any reason why the man should not be approached for the study. If no such reason was given, we sent the man an introductory letter and followed up with a telephone call to assess final eligibility and recruit the man into the study.

Of the 574 eligible men diagnosed with TGCC during the study period, 391 completed an interview (68.1% participation proportion). The primary reasons for non-participation were refusal (64.5%), a move out of the study area or inability to contact (26.2%), physician request that the subject not be contacted (6.0%), and death (3.3%). Approximately 7% and 2.5% of cases <30 and 30–44 years old, respectively, were ineligible because they did not possess a landline telephone.

Controls

We used Mitofsky-Waksberg RDD with a clustering factor (“k”) of five to identify and recruit controls (15–17). Men were eligible to serve as controls if they did not have a history of TGCC and resided in the same three counties of Washington State as the cases during the case diagnosis period. We attempted to select controls so that they would be frequency-matched to the cases on five-year age groups using one-step recruitment (18). Each phone number was called at least nine times over two or more weeks, including weekday, weekend, and evening calls. When a call was answered, the interviewer sought to determine whether the phone rang in a residence and was a landline telephone, the county of the residence, and whether a man 18–44 years of age lived in the residence. If the household census identified an eligible man, the interviewer attempted to obtain the name and address of the man so that a letter introducing the study could be sent to him. Following the mailing of the letter, an interviewer called the man to screen him for final eligibility and recruit him into the study.

We were able to determine the residential status of all but 3,340 (5.8%) of the 57,948 numbers called; <20% of these telephone numbers would have been expected to be associated with residential addresses (19). For 14,046 (82.0%) of the 17,132 telephone numbers belonging to a residence, we determined whether an eligible (i.e., age and county eligible and able to communicate in English) man resided there. Of the 1,963 eligible men identified, 1,023 were

interviewed(52.1%); 925 men refused and 15 men were lost to follow-up. The overall control response proportion(screening response $\times$ interview response) was 42.7%.

Interviews

After providing written informed consent, cases and controls were interviewed in person using a structured questionnaire. All questions referred to the time period prior to each man's assigned reference date. For each case, the reference date was the month and year of his TGCC diagnosis. Each control was assigned a reference date selected at random from among all possible dates given the distribution of diagnosis years of cases identified at the time of selection of the control via RDD. Information collected during the interview included: 1) demographic characteristics; 2) medical history and family history of cancer; 3) known or suspected risk factors for TGCC, including recreational PA.

To assess PA during adolescence, we collected information using a modification of the Historical Physical Activity Questionnaire (20,21). The original questionnaire was modified to focus on competitive sports, PA suspected of being sources of testicular trauma ("riding activities," described below), and several summary measures of PA performed during grades 7–12. Participants listed all competitive athletic activities in which they participated, either alone or on a team, the number of years for each sport, and the average number of months per year. We calculated the total duration of participation for the most commonly reported sports (baseball, basketball, football, soccer, wrestling, and track and field) by multiplying the months per year times the number of years. Total duration of participation in all competitive sports combined was calculated by summing the number of months for each sport across all sports reported.

For each riding activity (e.g., riding a bike for transportation; mountain biking or trail biking; riding horses; and riding a motorized bike such as a moped, motorcycle, or dirt bike), participants reported the number of times per month or week and number of years that they usually performed each activity. Questions on mountain biking were added approximately 1 year after the start of recruitment; analyses for this activity include 314 cases and 857 controls. To estimate the average frequency of each riding activity over the 6-year period (grades 7–12), we multiplied the frequency per week or month by the number of years out of six and then divided by six. We then created a 4-level variable: none and then approximate tertiles based on the distribution in controls.

We collected information on frequency or duration of several measures of global PA: usual days per week of physical education classes in grades 7–8, 9–10, and 11–12 (three separate questions) and number of hours per day or week of: sedentary activity (watching television or videos or playing video games outside of school), moderate exercise or sports activities ("such as bowling, golf, or taking long walks"), and vigorous exercise or sports activities ("running, racket sports, swimming, aerobics, or other activities that increase your heart rate, and make you sweat and breathe hard") during grades 7–12. To create a frequency variable, we combined zero and one day per week and 4 and 5 days per week of physical education classes, to have sufficiently large categories for analysis; zero days of physical education class attendance was very uncommon in grades 7–10. We compute a weighted average number of days per week physical education classes were attended in grades 7–12. For this average as well as for sedentary, moderate exercise or sports activities, and vigorous exercise or sports activities, we computed quartiles based on the distribution of the controls.

We used unconditional logistic regression to calculate odds ratio (OR) estimates (which approximate the relative risk) of the association of TGCC and PA, along with 95% confidence intervals (CI). All analyses were adjusted for age (continuous), income (<\$25,000, \$25,000–<\$50,000, \$50,000–<\$90,000, $\geq$ \$90,000), race (white, non-white), and history of undescended

testes (none, 1–2). Each activity was further adjusted for all other activities. For example, moderate-intensity activities were additionally adjusted for categories of vigorous and sedentary activities, as well as duration of competitive sports. Each riding activity was adjusted for average frequency of all other riding activities. Frequency of physical education class was adjusted for moderate- and vigorous-intensity activity, sedentary activity, and months of competitive sports participation. Adjustment for additional characteristics such as body mass index (kg/m^2 , BMI), marijuana use, alcohol consumption, and family history of testicular cancer did not materially change OR estimates, so they were not included in final models.

To evaluate whether there was a monotonic relationship between each measure of PA and TGCC risk, we tested for trend by using a grouped linear variable, with each category coded as the median value in the controls for that category. In testing for trends, we included only those who reported some amount of a given activity. For PA without a “none” category (e.g., hours per week of moderate-intensity activity), all categories were included. To evaluate whether associations for activities that were commonly performed (e.g., bicycle riding) or those for which overall associations were observed (e.g. horseback riding) differed by histologic subtype (pure seminoma vs. other), we used polytomous logistic regression.

Because a history of undescended testis is such a strong TGCC risk factor, we also conducted analyses limited to men without such a history. In addition, we conducted analyses stratified by duration of competitive sports participation ($<$ median, $\geq$ median duration) and age at diagnosis (<35 years, ≥ 35) to evaluate whether associations differed by these characteristics.

RESULTS

Compared with controls, a larger proportion of TGCC cases were younger, white, had a lower education and income, reported a personal history of undescended testes, and a first degree family history of TGCC (Table 1). Cases and controls were similar in terms of BMI.

There were modest increases in TGCC risk associated with high levels of moderate-intensity PA (≥ 9 hrs/wk vs. <2 : OR=1.4, 95% CI: 0.9, 2.1, p-trend = 0.05) and intermediate duration of competitive sports participation (23–47 months vs. none: OR=1.4, 95% CI: 1.0, 2.2), while there was no association for the highest category of duration (≥ 48 months vs. none, OR = 1.2, 95% CI: 0.8, 1.7) (Table 2). Relative to men who reported not playing each sport, those who played soccer or basketball for 1–8 months (the 1st tertile of duration for each sport) had increased TGCC risks (for soccer: OR=1.9, 95% CI 1.2–3.1, p-trend = 0.21; for basketball: OR=1.5, 95 CI 1.0–2.2, p-trend = 0.38), with no association for those who played more (not tabulated). Compared to men who had not wrestled, those who wrestled competitively for 6–11 months had a decreased TGCC risk (OR=0.4, 95% CI: 0.2, 0.8); the association was weaker for the highest duration category (≥ 12 months: OR=0.8, 95% CI: 0.4, 1.4, p-trend = 0.34) (not tabulated). Duration of baseball, football, and track and field were not associated with TGCC risk (data not presented). Neither high levels of vigorous-intensity activity nor hours of sedentary activity were associated with TGCC risk.

Bicycle riding for transportation was not associated with TGCC risk (Table 3). There was a weak inverse association between greater average frequency of mountain biking and TGCC risk (≥ 4 times/month vs. none: OR=0.6, 95% CI 0.3–1.1, p=0.08). Intermediate duration (3–4 years vs. none: OR = 0.4, 95% CI: 0.2, 0.8) and more frequent horseback riding (≥ 1 time/month vs. none: OR = 0.6, 95% CI: 0.3, 1.0) were also associated with decreased TGCC risks; longer duration of horseback riding (5–6 years vs. none: OR = 1.0, 95% CI: 0.5, 1.7), however, was not associated with a decreased TGCC risk, and there was no evidence of a trend (p-trend for duration = 0.87). Neither frequency nor duration of riding a motorized bicycle was associated

with TGCC risk. Frequencies of physical education class were not associated with TGCC risk (data not presented).

Greater weekly duration of moderate-intensity activity (but not vigorous) was associated with an increased risk of non-seminoma/mixed tumors (≥ 9 hrs vs. <2 , p for trend = 0.006), but was not associated with seminomas (Table 4). Compared to no bicycle riding, infrequent bicycle riding (>0 – <1.44 days/wk) was associated with a slightly elevated risk of seminoma, while there was no evidence of an increased risk for more frequent riding. Results remained largely the same after excluding those with a history of undescended testes. There was no evidence of effect modification by duration of competitive sports participation or age at diagnosis (data not presented).

DISCUSSION

Two broad mechanisms have stimulated research on PA and TGCC risk. The first mechanism relates to physical activity's potential effects on androgenic hormones. PA has been associated both with increases (22,23) and decreases (24,25) in androgen levels immediately following a bout of exercise, possibly depending on the type, intensity, and duration of activity. In one study, the changes were only apparent after maximal, but not submaximal exercise bouts (26). Results from studies designed to assess longer term effects of exercise on hormone levels have been inconsistent; higher PA levels have been associated with higher testosterone levels (27–29), lower testosterone levels (30), as well as no difference in hormone levels after accounting for differences in age, BMI, and race (31). Thus, the relationship between long-term exercise at a moderate level and hormone levels in men is unclear. To the extent that TGCC is etiologically related to androgens, one could hypothesize that PA could either increase or decrease the risk of TGCC.

A second proposed hypothesis is that PA such as bicycling or horseback riding could result in testicular trauma or injury that is sufficient to cause testicular atrophy, a putative risk factor for TGCC (5–7). Atrophy may increase TGCC risk by disturbing the local hormonal milieu or by causing a release of inflammatory and growth factors, increasing the opportunity for the growth of preneoplastic cells (32). Nevertheless, there is little empirical evidence to support an etiologic role for trauma or injury, due at least in part to the difficulty in measuring either subclinical trauma or injury (such as that possibly caused by cycling or horseback riding) in epidemiologic studies. Men with TGCC may be more likely to recall and report injuries than men without TGCC. Furthermore, clinically recognized trauma may increase the likelihood of diagnosing an otherwise asymptomatic TGCC, further complicating interpretation of these associations.

There are several limitations of the current study that should be considered when interpreting our results. First, information on PA was based on self-report. Although the parent questionnaire has been shown to have good reliability and validity (20,21,33,34), the modified version used in this study has not been similarly evaluated. Recall of historic activities is prone to error, which is a concern in this study, and in the other previously conducted case-control studies. For example, cases may have been more motivated to recall aspects of their past than were controls, and thus potentially report their exposures more accurately than controls. However, it seems implausible that differences in reporting accuracy between cases and controls could explain our largely null results if PA was truly positively associated with TGCC risk, which would have required that cases be *less* likely to report PA than controls. Nevertheless, non-differential misclassification could possibly explain null results.

A second limitation is that the proportion of eligible cases and controls who participated was relatively low. In order to assess potential selection bias, we collected a limited amount of

information from case non-participants (n=47) and control non-participants (n=196) via a telephone interview, including information on hours/wk of vigorous PA in grades 7–12. To simplify comparisons, we created a 2-level category of <14 hours/wk (combining the first three categories presented in Table 2) and ≥ 14 hours/wk. Although not statistically significant, case non-participants were less likely to report the highest level of vigorous PA compared to case participants (24.4% vs. 31.2%, $p=0.35$), while control non-participants were more likely to report the highest level of PA than control participants (34.2% vs. 28.7%, $p=0.17$). Note that data from non-participants and participants were obtained using a different mode (over the telephone for non-participants and via an in-person interview for participants) and were asked in a different order. The effects of these differences are difficult to ascertain. Nonetheless, to estimate the prevalence of ≥ 14 hours/wk vigorous activity in the absence of non-response, we weighted the participant and non-participant prevalences to obtain an overall prevalence (assuming that the non-participants who completed the telephone interview were representative of all non-participants). In controls, based on a prevalence of 28.7% in participants and a 42.7% response proportion: $(28.7\% \times 0.427) + (34.2\% \times 0.573)$, the true prevalence would be approximately 31.9%. For cases, the corresponding estimate is $(31.2\% \times 0.681) + (24.4 \times 0.319) = 29.0\%$. Based on these estimates, the true OR would equal 0.87 (versus an OR=1.1 without such adjustment for non-participation). If we do not assume that interviewed non-participants were representative of all non-participants, for selection bias to have masked an increased risk (e.g., an OR ≥ 1.4), $\leq 20\%$ of the non-interviewed case non-participants and $\leq 15\%$ of the non-interviewed control non-participants would have had to perform ≥ 14 hours/wk of vigorous activity. It seems unlikely that the vigorous activity in the non-participant controls would be so much lower than in the participating controls or the interviewed control non-participants. Thus, even if there is some selection bias, this bias is unlikely to change our overall conclusion that high levels of PA during adolescence are not associated with an increased TGCC risk.

A strength of the current study is that we collected detailed information on type, duration, and frequency of PA sufficient to evaluate potential “dose”-response associations. Furthermore, the questionnaire also collected detailed information on activities that might be potential sources of testicular trauma or injury to try to replicate results from prior studies. However, the relatively large number of activities led to exploration of several statistical models and more hypothesis testing, possibly increasing the number of spuriously statistically significant inverse or positive associations.

Keeping these limitations and strengths in mind, the pattern of associations across activities in the current study was not consistent with those expected if associations were causal. For example, high levels of moderate-intensity activity and intermediate duration of competitive sports were associated with increased risks, but high levels of vigorous-intensity activity and longer duration of competitive sports were not. Infrequent mountain biking and horseback riding were associated with decreased risks, but similar activities (for example, bicycling for recreation or transportation) performed more frequently, were not.

Our essentially null results are not entirely surprising. Although several studies (5–7) observed increased risks associated specifically with cycling and/or other riding activities, in only one of the studies (7), did the CI's for the association exclude one. In the study by Gallagher and colleagues, cycling was inversely associated with TGCC risk; however, those who participated in two or more riding activities (horseback riding, motorcycling, and snow mobiling, which, individually, were not associated with TGCC) had a 60% elevated risk (95% CI 1.1–2.4). Thus, though intriguing, results from these studies implicating riding activities are neither particularly consistent nor strong. Studies that have reported global measures of PA have observed decreased (5,10,35) and increased (8) TGCC risks, consistent with up to a 40% reduction in risk or a more than doubling in risk. Although there is some consistency within studies (e.g.,

elevated risks for moderate and high-intensity activity (8) or decreased risks for vigorous activity and increased risks for sedentary activity (35)), there are also large inconsistencies within some studies (e.g., 40–50% reduced risk based on maternal report and weakly elevated risks based on son's (personal) report in a mother-son matched pair case control study (10)), and only weak evidence of dose-response associations overall (5). Inconsistency across studies may be due in part to differences in sample size (from as few as 90 cases to as many as 794 cases), eligibility criteria (limited to men <45 years at diagnosis/reference vs. all ages; all TGCC cases or seminomas only), source of controls (population-based vs. hospital-based, detailed PA assessment or global measures only, and controlling for confounding. Furthermore, most prior studies produced estimates with wide CIs that included, or barely excluded, the null value, suggesting uncertainty in estimates and true associations that are likely to be relatively modest.

In sum, our study, which was relatively large, population-based, collected detailed information on PA, and used a rigorous method to sample controls, provides little consistent support for an association between high levels of overall PA in adolescence and future risk of TGCC. We also found no evidence to suggest that participating in activities that are potential sources of testicular trauma increase TGCC risk. There is a need for a better understanding of effects of both moderate and vigorous total PA and specific types of PA on hormones in adolescence and their potential effects on the etiology of testicular cancer. Epidemiologic studies of TGCC risk using validated measures of PA may also help to clarify associations and reduce concerns of measurement error and bias.

Abbreviations

BMI	Body mass index
CI	Confidence interval
OR	Odds ratio
PA	physical activity
RDD	random digit dialing
TGCC	testicular germ cell cancer

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Table 1

Selected Characteristics Among Testicular Cancer Cases and Controls

Characteristic	Cases (n=391)		Controls (n=1023)	
	N	%	N	%
Age at diagnosis (years)				
18–24	57	14.6	127	12.4
25–29	62	15.9	132	12.9
30–34	103	26.3	257	25.1
35–39	87	22.3	259	25.3
40–44	82	21.0	248	24.2
Race/ethnicity				
White, non-Hispanic	343	87.7	820	80.2
African American, non-Hispanic	0	0.0	29	2.8
White, Hispanic	14	3.6	28	2.7
Other, non-Hispanic	27	6.9	121	11.8
Other Hispanic	7	1.8	25	2.4
Education				
Less than a high school education	27	6.9	68	6.6
High school graduate	78	19.9	169	16.5
Some college	129	33.0	324	31.7
College graduate or more	157	40.2	462	45.2
Income (\$) ^a				
<25,000	58	14.9	112	11.0
25,000–49,999	116	29.7	243	23.8
50,000–89,999	132	33.3	416	40.8
≥ 90,000	86	22.1	248	24.3
Body mass index at reference (kg/m ²)				
<25	145	37.1	372	36.4
25.0–29.9	179	45.8	448	43.8
30–34.9	48	12.3	153	15.0
35	19	4.9	50	4.9
Undescended testes ^b				
No	350	90.4	999	97.7
Yes	38	9.6	34	2.4
Unilateral	22	5.7	11	1.1
Bilateral	7	1.8	8	0.8
Unknown	8	2.1	5	0.5
First degree family relative with testicular cancer				
No	332	84.9	901	88.1
Yes	9	2.3	11	1.1
Don't know or missing	50	12.8	111	10.9

^aMissing for 1 case and 4 controls

^bMissing for 4 cases and 0 controls

Table 2

Sedentary, Moderate- and Vigorous-Intensity, and Competitive Activities in Adolescence (Grades 7–12) and Testicular Germ Cell Cancer Risk

Characteristic	Cases	Controls	OR	95% CI
	N (%)	N (%)		
Moderate-intensity activities (hrs/wk)				
<2	54 (13.8)	164 (16.0)	1.0	Ref
2–<5	105 (26.9)	294 (28.7)	1.1	0.7, 1.6
5–<9	110 (28.1)	302 (29.5)	1.2	0.8, 1.7
≥9	122 (31.2)	263 (25.7)	1.4	0.9, 2.1
<i>p for trend</i>				0.05
Vigorous-intensity activities (hrs/wk)				
<5	85 (21.7)	218 (21.3)	1.0	Ref
5–<10	98 (25.1)	268 (26.2)	0.9	0.6, 1.4
10–<14	86 (22.0)	243 (23.8)	0.9	0.6, 1.3
≥14	122 (31.2)	294 (28.7)	1.0	0.7, 1.5
<i>p for trend</i>				0.63
Sedentary activities (hrs/wk)				
<7	39 (10.0)	131 (12.8)	1.0	Ref
7–<14	90 (23.0)	229 (22.4)	1.3	0.8, 2.0
14–<21	131 (33.5)	347 (33.9)	1.2	0.8, 1.8
≥21	131 (33.5)	316 (30.9)	1.3	0.8, 2.0
<i>p for trend</i>				0.45
Duration of competitive sports (months)				
None	64 (16.4)	179 (17.5)	1.0	Ref
1–23	90 (23.0)	235 (23.0)	1.1	0.8, 1.7
24–47	110 (28.1)	247 (24.1)	1.4	1.0, 2.2
≥48	127 (32.5)	362 (35.4)	1.2	0.8, 1.7
<i>p for trend</i>				0.75

Adjusted for age (continuous), income (<\$25,000, \$25,000–<\$50,000, \$50,000–<\$90,000, ≥\$90,000), race (white, non-white), history of undescended testes (none, ≥1), and other types of PA and sedentary activities

Table 3

Bicycling, Horseback Riding, and Motor Biking in Adolescence (Grades 7–12) and Testicular Germ Cell Cancer Risk

Characteristic	Cases	Controls	OR	95% CI
	N (%)	N (%)		
Bicycling for transportation				
No	141 (36.1)	365 (35.7)	1.0	Ref
Yes	250 (63.9)	658 (64.3)	1.0	0.7, 1.3
Duration of bicycling for transportation (years)				
None	141 (36.1)	365 (35.7)	1.0	Ref
1–2	58 (14.8)	137 (13.4)	1.1	0.8, 1.6
3–4	110 (28.1)	296 (28.9)	0.9	0.7, 1.3
5–6	82 (21.0)	225 (22.0)	0.9	0.6, 1.3
<i>P for trend</i>				0.42
Average frequency (days/wk) of bicycling for transportation during 6-yr period				
None	141 (36.1)	365 (35.7)	1.0	Ref
>0–<1.54	97 (24.8)	237 (23.2)	1.0	0.7, 1.4
1.54–<3.46	68 (17.4)	200 (19.6)	0.9	0.6, 1.3
≥ 3.46	85 (21.7)	221 (21.6)	1.0	0.7, 1.3
<i>P for trend</i>				0.82
Mountain biking ^a				
No	263 (83.8)	734 (83.7)	1.0	Ref
Yes	51 (16.2)	143 (16.3)	0.9	0.6, 1.3
Duration of mountain biking (years) ^a				
None	263 (83.8)	734 (83.7)	1.0	Ref
1–2	19 (6.1)	46 (5.2)	1.1	0.6, 1.9
3–4	21 (6.7)	61 (7.0)	0.9	0.5, 1.5
5–6	11 (3.5)	36 (4.1)	0.7	0.4, 1.5
<i>P for trend</i>				0.50
Average frequency (times/month) of mountain biking during 6-yr period ^a				
None	263 (83.8)	734 (83.7)	1.0	Ref
>0–<1	13 (4.1)	37 (4.2)	0.9	0.4, 1.7
1–<4	27 (8.6)	56 (6.4)	1.2	0.7, 2.0
≥ 4	11 (3.5)	50 (5.7)	0.6	0.3, 1.1
<i>P for trend</i>				0.08
Average frequency (days/wk) of bicycling for transportation or mountain biking ^a				
None	100 (31.3)	298 (33.4)	1.0	Ref
>0–<1.44	83 (26.0)	193 (21.7)	1.2	0.8, 1.7
1.44–<3.46	63 (19.7)	195 (21.9)	1.0	0.7, 1.5
≥3.46	73 (22.9)	205 (23.0)	1.0	0.7, 1.5
<i>P for trend</i>				0.43

Characteristic	Cases	Controls	OR	95% CI
	N (%)	N (%)		
Horseback riding				
No	323 (82.6)	813 (79.5)	1.0	Ref
Yes	68 (17.4)	210 (20.5)	0.8	0.6, 1.1
Duration of horseback riding(years)				
None	323 (82.6)	813 (79.5)	1.0	Ref
1–2	37 (9.5)	91 (8.9)	1.1	0.7, 1.6
3–4	11 (2.8)	67 (6.5)	0.4	0.2, 0.8
5–6	20 (5.1)	52 (5.1)	1.0	0.5, 1.7
<i>p for trend</i>				0.87
Average frequency of horseback riding over the 6-year period				
None	323 (82.6)	813 (79.5)	1.0	Ref
>0<2 times/yr	23 (5.9)	58 (5.7)	1.1	0.6, 1.8
2 times/yr<1 time/month	27 (6.9)	73 (7.1)	0.9	0.6, 1.5
≥ 1 time/month	18 (4.6)	79 (7.7)	0.6	0.3, 1.0
<i>p for trend</i>				0.06
Motorized bike riding				
No	247 (63.2)	614 (60.0)	1.0	Ref
Yes	144 (36.8)	409 (40.0)	0.9	0.7, 1.2
Duration of motorized bike riding (years)				
None	247 (63.2)	614 (60.0)	1.0	Ref
1–2	55 (41.1)	169 (16.5)	0.8	0.6, 1.1
3–4	44 (11.3)	110 (10.8)	1.0	0.7, 1.5
5–6	45 (11.5)	130 (12.7)	1.0	0.7, 1.4
<i>p for trend</i>				0.55
Average frequency (times/month) of motorized bike riding over the 6-year period				
None	247 (63.2)	614 (60.0)	1.0	Ref
>0<1	51 (13.0)	127 (12.4)	1.0	0.7, 1.5
≥ 1<5	49 (12.5)	151 (14.8)	0.8	0.5, 1.2
≥ 5	44 (11.3)	131 (12.8)	0.9	0.6, 1.4
<i>p for trend</i>				0.86

Adjusted for age (continuous), income (<\$25,000, \$25,000–<\$50,000, \$50,000–<\$90,000, ≥\$90,000), race (white, non-white), history of undescended testes (none, ≥) and total months of participation in competitive sports during grades 7–12 (none, 1–23, 24–47, ≥48). Each activity additionally adjusted for categories of average frequency over the 6-year period of all other activities in the table.

^a Analyses of mountain biking include 314 cases and 857 controls because this question was added to the questionnaire in 2002.

Table 4
Selected Measures of Physical Activity in Adolescence (Grades 7–12) and Testicular Germ Cell Cancer Risk, by Histologic Subtype

Days per week of physical education classes	Controls (n=1003)		Pure Seminoma (n=242)		OR (95% CI)	Non-seminoma/mixed (n=149)		OR 95% CI
	N (%)	N (%)	N (%)	N (%)		N (%)		
Moderate-intensity activities (hrs/wk) ^a								
<2	164 (16.0)	37 (15.4)	1.0 (ref)	17 (11.3)	1.0 (ref)	1.0 (ref)		
2<5	294 (28.7)	71 (29.5)	1.0 (0.7–1.7)	34 (22.7)	1.0 (0.7–1.7)	1.1 (0.6–2.2)		
5<9	302 (29.5)	62 (25.7)	0.9 (0.6–1.5)	48 (32.0)	0.9 (0.6–1.5)	1.7 (0.9–3.1)		
≥9	263 (25.7)	71 (29.5)	1.1 (0.7–1.8)	51 (34.0)	1.1 (0.7–1.8)	2.1 (1.1–3.9)		
<i>p for trend</i>			0.55			0.006		
Vigorous-intensity activities (hrs/wk) ^a								
<5	218 (21.3)	56 (23.2)	1.0 (ref)	29 (19.3)	1.0 (ref)	1.0 (ref)		
5<10	268 (26.2)	60 (24.9)	0.9 (0.6–1.4)	38 (25.3)	0.9 (0.6–1.4)	1.0 (0.6–1.7)		
10<14	243 (23.8)	49 (20.3)	0.8 (0.5–1.3)	37 (24.7)	0.8 (0.5–1.3)	1.0 (0.5–1.8)		
≥14	294 (28.7)	76 (31.5)	1.1 (0.7–1.7)	46 (30.7)	1.1 (0.7–1.7)	1.0 (0.6–1.8)		
<i>p for trend</i>			0.52			0.94		
Average frequency of bicycling for transportation or mountain biking (days/wk) ^b								
None	298 (33.4)	49 (26.1)	1.0 (ref)	51 (38.9)	1.0 (ref)	1.0 (ref)		
>0<1.44	193 (21.7)	49 (26.1)	1.5 (1.0–2.4)	34 (26.0)	1.5 (1.0–2.4)	0.9 (0.5–1.5)		
1.44<3.46	195 (21.9)	41 (21.8)	1.3 (0.8–2.0)	22 (16.8)	1.3 (0.8–2.0)	0.8 (0.4–1.3)		
≥3.46	205 (23.0)	49 (26.1)	1.3 (0.8–2.1)	24 (18.3)	1.3 (0.8–2.1)	0.7 (0.4–1.3)		
<i>p for trend</i>			0.54			0.62		
Average frequency of horseback riding over the 6- year period ^c								
None	813 (79.5)	192 (79.7)	1.0 (ref)	131 (87.3)	1.0 (ref)	1.0 (ref)		
>0<2 times/yr	58 (5.7)	16 (6.6)	1.3 (0.7–2.4)	7 (4.7)	1.3 (0.7–2.4)	0.7 (0.3–1.7)		
2 times/yr<1 time/month	73 (7.1)	20 (8.3)	1.0 (0.6–1.8)	7 (4.7)	1.0 (0.6–1.8)	0.6 (0.3–1.4)		
≥ 1 time/month	79 (7.7)	13 (5.4)	0.6 (0.3–1.2)	5 (3.3)	0.6 (0.3–1.2)	0.5 (0.2–1.3)		
<i>p for trend</i>			0.06			0.94		

Adjusted for age (continuous), income (<\$25,000, \$25,000–<\$50,000, \$50,000–<\$90,000, ≥\$90,000), race (white, non-white), and history of undescended testes (none, ≥1)

^a Additionally adjusted for hrs/wk of moderate-intensity activities (<2 , $2-<5$, $5-<9$, ≥ 9), hrs/wk of vigorous-intensity activity (<5 , $5-<10$, $10-<14$, ≥ 14), hrs/wk of sedentary activities (<7 , $7-<14$, $14-<21$, ≥ 21), and total months of participation in competitive sports during grades 7–12 (none, 1–23, 24–47, ≥ 48).

^b Additionally adjusted for categories of average frequency over the 6-year period of bicycling for transportation, horseback riding, and motor biking

^c Additionally adjusted for categories of average frequency over the 6-year period of horseback riding and motor biking