Link between Physical Activity Type in Adolescence and Body Composition in Adulthood

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ABSTRACT

BELANGER, M., T. R. KATAPALLY, T. A. BARNETT, E. O'LOUGHLIN, C. M. SABISTON, and J. O'LOUGHLIN. Link between Physical Activity Type in Adolescence and Body Composition in Adulthood. *Med. Sci. Sports Exerc.*, Vol. 50, No. 4, pp. 709–714, 2018. **Purpose**: We investigated whether type of physical activity (PA) (sports, running, and fitness/dance) engaged in during adolescence is associated with body composition in late adolescence or early adulthood. **Methods**: Data were drawn from 631 participants in the Nicotine Dependence in Teens study, a prospective investigation of students ages 12–13 yr at inception. Self-report PA data were collected at baseline, in grade 7, and every 3–4 months thereafter during the 5 yr of high school (1999–2005). Anthropometric indicators (height, weight, waist circumference, triceps, and subscapular skinfold thickness) were measured at ages 12, 16, and 24 yr. On the basis of prior exploratory factor analysis, PA was categorized into one of three types (sports, running, and fitness/dance). Regression models estimated the association between number of years participating in each PA type (0–5 yr) during high school and body composition measures in later adolescence or early adulthood. **Results**: In multivariable models accounting for age, sex, and parent education, more number of years participating in running during adolescence was associated with lower body mass index, waist circumference, and skinfold thickness in later adolescence and early adulthood (all $P < 0.01$). This association was no longer apparent in models that accounted for body composition at age 12 yr. The number of years participating in sports was positively associated with body mass index in early adulthood ($P = 0.02$), but fitness/dance was not statistically significantly associated with any outcome. **Conclusion**: Sustaining participation in running, but not in other PA types, during adolescence was related to lower body composition in later adolescence and adulthood. However, more research is needed to determine whether this association is attributable to a relationship between PA and body composition in early adolescence. **Key Words:** RUNNING, SPORTS, DANCE AND FITNESS, YOUTH, BMI

EPIDEMIOLOGY

Most adolescents do not accumulate recommended levels of physical activity (PA). Further, PA levels decrease markedly during adolescence, especially in girls (1–3), and decreasing PA between adolescence and early adulthood is associated with greater weight gain later in life (4–7). By contrast, high PA levels during adolescence are associated with a lower likelihood of excess weight in adulthood (4,8). Individuals can accumulate PA by participating in different types of PA, including exercise, sports, active transportation, occupational activities, domestic chores, and leisure activities (1). However, few studies distinguish between types of PA in assessing the relationship between PA and weight status. Rather, PA overall is investigated with quantity, intensity, or duration expressed as a composite score across all PA types.

Identifying which PA types are linked to weight status may inform the development of more effective interventions (9,10). Menschik et al. (11), for example, found that frequent participation in team sports during adolescence was associated with a lower probability of being overweight as an adult, while jogging, walking, karate, gymnastics, and dancing did not have protective effects.

Previous studies suggest that sustained participation in specific types of PA throughout adolescence varies by PA type (1,12). Regular participation in sports and running is related to higher PA levels in adulthood, whereas no such tracking was observed for fitness or dance activities (13).

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Submitted for publication June 2017.
Accepted for publication November 2017.

0195-9131/18/5004-0709/0
MEDICINE & SCIENCE IN SPORTS & EXERCISE®

DOI: 10.1249/MSS.0000000000001503

Because of differences in average energy costs (14), contributions to muscle development (11), the association with cardiovascular fitness (15), and the effects on other exercise-related physiological adaptations (16,17), it is possible that different types of PA are associated with different probabilities of weight gain. However, grouping PA by type is challenging because PA has numerous attributes, including intensity, purpose, setting, organization, and competitiveness (13), and it can be categorized according to each attribute. In exploratory factor analysis, Belanger et al. (13) identified three natural groupings of PA: sports, running, and fitness/dance. Building on these findings, the aim of this study was to investigate whether sustained participation in any of these three natural PA groupings during adolescence is associated with body composition in late adolescence or early adulthood.

METHODS

Data were drawn from the ongoing Nicotine Dependence in Teens study, a prospective investigation of 1294 grade 7 students ages 12–13 yr at inception. Self-report data (including on PA) were collected at baseline in 1999 in grade 7 and every 3–4 months thereafter during the 5 yr of high school, for a total of 20 possible data collection cycles per student. In cycles 1 to 20, participants completed questionnaires in French or English in a classroom setting or as a larger group in the school cafeteria. Data collectors visited schools twice during each cycle, so that participants absent on the first day could complete the questionnaire on the second day. Two post–high school data collections were conducted in 2007–2008 and 2011–2012 (cycles 21 and 22) when participants were ages 20 and 24 yr on average, respectively. Anthropometric indicators (height, weight, waist circumference, triceps, and subscapular skinfold thickness) were measured by trained technicians at ages 12, 14, 16, and 24 yr (i.e., cycles 1, 12, 19, and 22, respectively). A detailed description of the Nicotine Dependence in Teens methods is available elsewhere (18).

The current analysis was restricted to participants who provided data in at least four of the first 5 yr of data collection, and who provided anthropometric data in early (age 12.3 ± 0.41 yr) and later adolescence (age 16.4 ± 0.62 yr) as well as in early adulthood (age 24.2 ± 0.37 yr). At recruitment, all participants provided assent, and their parents or guardians provided signed informed consent. Participants provided consent in the post–high school data collection cycles. The study received ethics approval from the Montreal Department of Public Health Ethics Review Committee, the McGill University Faculty of Medicine Institutional Review Board, and the Centre de Recherche du Centre Hospitalier de l'Université de Montréal.

Study Variables

Type of PA. In cycles 1 to 20, participants self-reported number of PA sessions per week in a 7-d recall, which was adapted from the Weekly Activity Checklist (19) by including activities commonly engaged in by adolescents residing in Montreal. At each cycle, adolescents were asked, "Think about the physical activities that you did last week from Monday to Sunday outside your regular gym class at school. For each activity that you did for 5 min or more at one time, mark an "X" to show the day(s) on which you did that activity," followed by a list of 29 activities. The 5-min criterion is supported by findings that moderate to vigorous physical activity sessions of this duration protect against obesity in youth (20). In cycle 1, the PA recall was administered twice over 2 wk in a subsample of 76 students in one school. The correlation between the reported number of PA sessions in the two administrations was $r = 0.73$, which is comparable with the test–retest reliability of accelerometers in similar populations (21).

Data from the recall were used to create groupings of types of PA as described elsewhere (13). Briefly, exploratory factor analysis was used to identify natural groupings among the 26 PA reported by participants (indoor and outdoor chores were deemed nonleisure and nondiscretionary and therefore excluded; walking was excluded because it was reported by nearly all participants in each cycle). Factors were retained based on examination of Scree plots and a minimum eigenvalue of 1, and variables with factor loading < 0.4) (i.e., swimming, outdoor play, and exercise/physical conditioning [push-ups, sit-ups, jumping jacks, weight lifting, exercise machines]) were excluded (13). Three PA types were identified and labeled "sports" (including eight sport-related activities: ice hockey, ice skating, football, rollerblading/skateboarding, basketball, soccer, boxing, and baseball), "fitness/dance" (including jazz dance, dancing, gymnastics, and games), and "running" (including running and mixed walking, which includes hiking and walking mixed with jogging). Participation in a PA type in a specified year was defined as reporting a minimum of three sessions per week in at least one cycle for that year (other definitions using a minimum of one, two, four, or five sessions per week yielded similar results). Participants were then categorized as having reported involvement in each PA type over 0, 1, 2, 3, 4, or 5 yr during high school. Involvement in one PA type was not strongly related to involvement in another PA type (i.e., Spearman rank correlation coefficients were $r = 0.1$ between number of years participating in sports and fitness/dance was, $r = 0.3$ between sports and running, and $r = 0.3$ between the fitness/dance and running). All PA types could therefore be included in the same multivariable model (13).

Body composition. Height and weight (Seca Portable Stadiometer—Model 214 and Seca Scale—Model 761; Seca Corporation, Columbia, MD), waist circumference, and triceps and subscapular skinfold thickness (Lange Skinfold Caliper, Beta Technology Inc., Cambridge, MD) were measured by trained technicians using a standard protocol (22). Two measures of height and waist circumference to the nearest 0.1 cm, weight to the nearest 0.2 kg, and triceps and subscapular skinfold thickness to the nearest 0.5 mm were obtained for each participant. If discrepancies greater than 0.5 cm for height and waist circumference, 0.2 kg for weight, or 1.0 mm for triceps and subscapular skinfold thickness were observed between the two measures, a third measure was obtained. The average of the two closest measures was recorded. To assess

TABLE 1. Demographic and body composition characteristics of study participants.

	Early Adolescence (Cycle 1)	Late Adolescence (Cycle 19)	Early Adulthood (Cycle 22)
Male, %	46	–	–
Age, mean ± SD, yr	12.3 ± 0.41	16.4 ± 0.62	24.2 ± 0.37
One or both parents with university degree, %	64	–	–
BMI, mean ± SD, $kg \cdot m^{-2}$	*N* = 631	*N* = 628	*N* = 589
Male	20.0 ± 3.73	21.7 ± 3.79	22.7 ± 3.80
Female	19.9 ± 4.00	21.5 ± 3.60	22.3 ± 3.79
Waist circumference, mean ± SD, cm	*N* = 630	*N* = 627	*N* = 591
Male	72.4 ± 10.32	77.4 ± 9.93	79.9 ± 9.71
Female	69.9 ± 10.03	74.2 ± 8.97	76.1 ± 9.46
Triceps and subscapular, mean ± SD, mm	*N* = 630	*N* = 626	*N* = 590
Male	23.1 ± 12.22	23.6 ± 10.62	28.0 ± 14.48
Female	25.4 ± 10.00	33.6 ± 11.09	39.5 ± 12.88

interrater reliability, we obtained repeated measures for a systematic one in 10 subsample of students at each cycle. Interrater reliabilities (split-half coefficients) of 0.99, 0.99, 0.98, 0.97, and 0.97 were observed for height, weight, waist circumference, triceps skinfold thickness, and subscapular skinfold thickness, respectively. Body mass index (BMI) was computed as weight divided by height squared ($kg \cdot m^{-2}$). The International Obesity Task Force criteria were used to derive BMI values with numerical cut points during adolescence to ensure consistency with adult BMI values (23). The sum of skinfolds was calculated by adding triceps and subscapular skinfold thickness (24).

Statistical Analyses

Separate multivariable linear regression models were developed for each measure of body composition to estimate the association between number of years participating in running, sports, or fitness/dance during adolescence and body composition measures in late adolescence or early adulthood. The number of years participating in a PA type was modeled as an interval variable in regressions but treated as a series of dummy variables for visual representation in figures. We used Spearman's partial correlation trend tests to explore the presence of trends. Quadratic terms representing "number of years participating in a PA type" were tested for potential nonlinear associations but were not significant and therefore not retained. Interaction terms to assess if the associations between PA type and body composition differed by sex were not significant, and therefore we did not stratify the analyses by sex. As determined through the use of directed acyclic graphs, all models were adjusted for age, sex, and parent education (both parents attended university, one parent attended university, and neither parent attended university). We used the generalized estimating equations framework to account for clustering at the school level (GENMOD procedure in SAS).

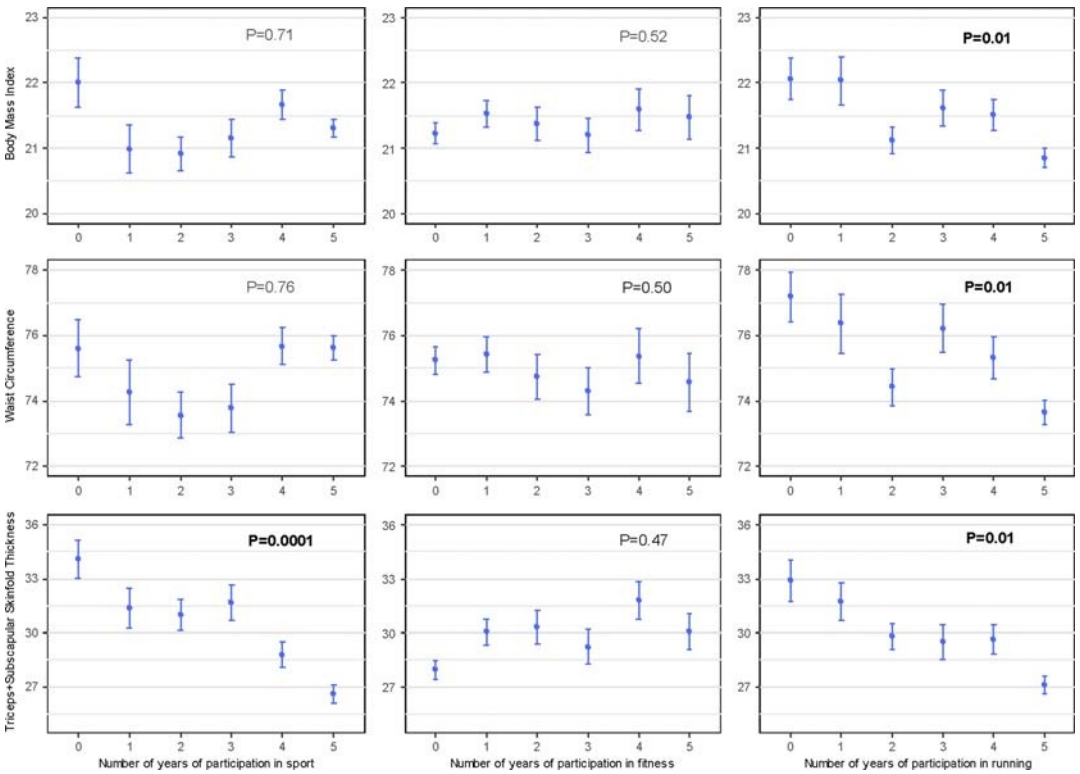

FIGURE 1—Mean BMI, waist circumference, and skinfold thickness in early adulthood in relation to number of years of participation in the three PA types during adolescence.

RESULTS

Of 1294 participants at baseline, 631 (54% girls) who provided data in at least four of the 5 yr of high school were included in the analyses (Table 1). There were increases in all measures of body composition during the 13-yr follow up.

A visual representation of data showed that consistent participation in running throughout adolescence was associated with decreases in all body composition measures between early and later adolescence ($P = 0.01$; Fig. 1). There was also a significant association between consistent participation in sports and decreases in skinfold thickness between early and later adolescence ($P = 0.0001$). These observations aligned with bivariate analyses showing that more number of years participating in running and sports was associated with lower skinfold thickness at all three time points (Table 2). Running was also associated with lower BMI and waist circumference in early and later adolescence, and number of years participating in sports was associated with a smaller waist circumference in early adulthood. The data suggested that more number of years participating in fitness/dance activities during adolescence was associated with greater skinfold thickness in later adolescence and early adulthood.

In multivariable linear regression analyses (Table 3) controlling for age, sex, and parent education, more number of years participating in running during adolescence was associated with lower BMI, waist circumference, and skinfold thickness in later adolescence and early adulthood. However, running was not significant in subsequent models that accounted for baseline measures of body composition. Although sports participation was not related to body composition in the initial multivariable model, the number of years participating in sports was a significant predictor of BMI in early adulthood with addition of a variable representing baseline body composition. This positive relationship suggests that more number of years participating in sports during adolescence was associated with higher BMI in early adulthood. Number of years participating in fitness/dance was not statistically associated with any body composition outcome in the multivariable models. All measures of body composition during early adolescence were positively associated with their respective measures of body composition during late adolescence and early adulthood.

DISCUSSION

There is evidence that higher PA levels in adolescence are inversely associated with body composition in adulthood (4,8,9). PA frequency, duration, and/or intensity are often the focus of study in research, and few investigations use measures of PA that distinguish type. Given that there is considerable individual variation in type of PA engaged in during adolescence (13), the purpose of this study was to investigate the association between sustained participation in different PA types during adolescence and body composition in adulthood (11). The data indicate that it may be relevant to consider attributes of PA other than intensity, duration, and

TABLE 2. Bivariate associations between types of PA and measures of body composition during early adolescence, late adolescence, and early adulthood.

	Early Adolescence			Late Adolescence			Early Adulthood		
	β	95% Confidence Interval	P	β	95% Confidence Interval	P	β	95% Confidence Interval	P
BMI									
Running	**−0.26**	**−0.442 to −0.077**	**0.005**	**−0.25**	**−0.431 to −0.082**	**0.004**	−0.14	−0.326 to 0.044	0.135
Sports	−0.07	−0.248 to 0.107	0.435	−0.03	−0.196 to 0.140	0.746	0.08	−0.095 to 0.260	0.364
Dance and fitness	0.11	−0.067 to 0.302	0.210	0.06	−0.116 to 0.237	0.500	0.02	−0.172 to 0.202	0.874
Age	**0.70**	**0.326 to 1.067**	**<0.001**	**0.45**	**0.053 to 0.854**	**0.026**	**0.56**	**0.086 to 1.038**	**0.021**
Boys	0.04	−0.570 to 0.643	0.906	0.13	−0.446 to 0.709	0.656	0.45	−0.164 to 1.062	0.151
Education	**−0.66**	**−1.300 to −0.022**	**0.043**	**−0.82**	**−1.434 to −0.210**	**0.008**	**−0.76**	**−1.427 to −0.090**	**0.026**
Waist circumference									
Running	**−0.72**	**−1.204 to −0.245**	**0.003**	**−0.60**	**−1.052 to −0.151**	**0.009**	−0.31	−0.785 to 0.163	0.198
Sports	0.05	−0.413 to 0.520	0.823	0.14	−0.294 to 0.576	0.524	**0.48**	**0.029 to 0.932**	**0.037**
Dance and fitness	−0.03	−0.514 to 0.460	0.914	−0.12	−0.572 to 0.338	0.613	−0.17	−0.650 to 0.306	0.481
Age	**1.69**	**0.705 to 2.674**	**<0.001**	0.73	−0.291 to 1.753	0.161	0.81	−0.406 to 2.019	0.192
Boys	**2.49**	**0.903 to 4.903**	**0.002**	**3.18**	**1.704 to 4.657**	**<0.001**	**3.77**	**2.225 to 5.314**	**<0.001**
Education	**−2.18**	**−3.890 to −0.467**	**0.013**	**−1.84**	**−3.445 to −0.230**	**0.025**	−1.49	−3.201 to 0.227	0.089
Triceps and subscapular skinfold thickness									
Running	**−0.87**	**−1.387 to −0.344**	**0.001**	**−1.38**	**−1.932 to −0.819**	**<0.001**	**−1.07**	**−1.783 to −0.352**	**0.003**
Sports	**−0.68**	**−1.188 to −0.175**	**0.008**	**−1.68**	**−2.210 to −1.156**	**<0.001**	**−1.83**	**−2.450 to −1.155**	**<0.001**
Dance and fitness	0.39	−0.141 to 0.914	0.151	**0.73**	**0.161 to 1.294**	**0.012**	**0.78**	**0.050 to 1.502**	**0.036**
Age	0.22	−0.877 to 1.312	0.697	−0.27	−1.600 to 1.054	0.687	0.09	−1.771 to 1.951	0.924
Boys	**−2.38**	**−4.109 to −0.643**	**0.007**	**−10.00**	**−11.706 to −8.297**	**<0.001**	**−11.51**	**−13.711 to −9.304**	**<0.001**
Education	**−2.45**	**−4.289 to −0.608**	**0.009**	**−2.50**	**−4.509 to −0.486**	**0.015**	**−4.230**	**−6.866 to −1.727**	**0.001**

Boldface indicates $P < 0.05$.
Education: one or both parents with university degree; running/sports/dance and fitness: number of years participating in a given type of PA.

TABLE 3. Multivariable relationships between types of PA during adolescence and measures of body composition during late adolescence and early adulthood.

	Late Adolescence				Early Adulthood			
	Model 1		Model 2		Model 1		Model 2	
Parameter (During Adolescence)	β	P	β	P	β	P	Estimate	P
BMI								
Age	**0.6070**	**<0.0001**	**0.6244**	**<0.0001**	**0.5755**	**<0.0001**	**0.5732**	**<0.0001**
Boys	0.4160	0.2239	−0.0525	0.5278	0.4290	0.2019	0.0142	0.8962
Parent education	**−0.6596**	**0.0391**	−0.0786	0.2952	**−0.6727**	**0.0345**	−0.0886	0.3769
Running	**−0.2761**	**0.0026**	0.0096	0.6663	**−0.2344**	**0.0096**	0.0294	0.3326
Sports	−0.0459	0.6737	0.0432	0.0814	−0.0065	0.9505	**0.0735**	**0.0252**
Fitness	0.1783	0.0774	−0.0096	0.6916	0.1435	0.1353	−0.0296	0.3333
BMI in early adolescence			**0.9389**	**<0.0001**			**0.9119**	**<0.0001**
Waist circumference								
Age	**1.6440**	**<0.0001**	**1.7390**	**<0.0001**	**1.5189**	**<0.0001**	**1.5525**	**<0.0001**
Boys	**3.7152**	**<0.0001**	**0.5246**	**0.0454**	**3.7177**	**<0.0001**	**0.9113**	**0.0047**
Parent education	**−1.8632**	**0.0251**	0.0549	0.8257	**−1.7186**	**0.0369**	0.1686	0.5995
Running	**−0.7714**	**0.0009**	0.0306	0.6842	**−0.6720**	**0.0030**	0.0523	0.5781
Sports	−0.1440	0.5990	0.0494	0.5010	−0.0152	0.9546	0.1273	0.1652
Fitness	0.4317	0.0984	0.0406	0.6040	0.3673	0.1344	0.0375	0.7045
Waist circumference in early adolescence			**0.9015**	**<0.0001**			**0.8534**	**<0.0001**
Triceps + subscapular skinfold thickness								
Age	**1.5933**	**<0.0001**	**1.7988**	**<0.0001**	**2.1297**	**<0.0001**	**2.2077**	**<0.0001**
Boys	**−4.8916**	**<0.0001**	**−3.9811**	**<0.0001**	**−6.8637**	**<0.0001**	**−5.6850**	**<0.0001**
Parent education	**−1.9312**	**0.0334**	0.0735	0.8148	**−2.4411**	**0.0118**	−0.2733	0.5072
Running	**−0.8675**	**0.0007**	−0.0953	0.3328	**−0.7738**	**0.0036**	−0.0633	0.6255
Sports	−0.4371	0.1380	−0.0713	0.4812	−0.4301	0.1598	−0.0953	0.4615
Fitness	0.3234	0.2412	−0.0589	0.5411	0.2048	0.4643	−0.1382	0.2676
Triceps + subscapular skinfold thickness in early adolescence			**0.8974**	**<0.0001**	**2.1297**		**0.9119**	**<0.0001**

Boldface indicates $P < 0.05$.
Parent education: one or both parents with university degree; running/sports/fitness: number of years participating in a given type of PA.

frequency (such as type) when assessing the longitudinal relationship between PA during adolescence and measures of body composition later in life. For example, participation in running during adolescence was associated with lower levels of all measures of body composition later on. However, running during adolescence was no longer a significant predictor of future body composition when body composition in early adolescence was taken into account. This is not entirely surprising because it is already established that body composition in early adolescence is a strong predictor of body composition later in life (25,26). These findings add to the evidence suggesting that it is critical that children and youth maintain a healthy weight and that children who are overweight are actively treated. Past systematic reviews demonstrate that effective healthy weight-promoting interventions in youth should be multicomponent, and that guided behavior modification endeavors include a PA component (27–29).

After adjustment for baseline body composition, we also noted that more number of years participating in sports during adolescence was associated with higher BMI in early adulthood. Because BMI was the only one of the three body composition measures to be significantly associated with sports participation in this study, it is possible that this relationship was related to increases in muscle rather than fat mass. It is well documented that in contrast to other measures of body composition such as skinfold thickness and waist circumference, measures of BMI can be associated with overestimation of body fat among lean individuals who have high muscle mass, such as athletes (30).

Our results differ from those of Menschik et al. (11) whose longitudinal study tracked youth for 5 yr between grades 8 and 12. They found that participation in physical education classes, several specific types of PA, and sports in high school was negatively associated with being overweight 5 yr later. However, there were important differences in the design, methods, and analysis between this study and our investigation. First, the study of Menschik et al. (11) incorporated only two data points (baseline and follow-up 5 yr later), whereas our study had more than 20 data collection cycles over 13 yr spanning ages 12–24 yr. Second, their study did not measure sustained PA over many years. By contrast, we measured the number of years each type of PA was reported throughout adolescence. Third, our study included three measures of body composition, whereas Menschik et al. (2008) used BMI only. Finally, body composition in early adolescence, which was the strongest determinant of body composition in early adulthood in our analysis, was not accounted for in the analysis of Menschik et al. (11).

Our finding of no association between sustained participation in any PA type during adolescence and body composition in later years should not diminish the importance of PA during adolescence. Other studies demonstrate that PA participation in early adolescence is linked to improved weight-related outcomes in adulthood, including a lower risk of developing the metabolic syndrome (31) and cardiovascular complications (4). However, because these studies did not adjust for body composition in adolescence, more research is needed to determine whether involvement of PA in the body composition regulation process during adolescence mediates the association between adolescent PA and adult health outcomes.

Strengths and limitations. Strengths of this study include the 13-yr follow-up, use of three objectives measures of body composition, and assessment of adolescent PA in 20 data collection cycles. Limitations include the use of self-report PA data. Misclassification of the exposures may have

biased our estimates toward the null. Generalizability to PA not included in the analyses is unknown. Loss to follow-up may have introduced selection bias, and the sample retained may not represent the target population.

CONCLUSION

Participation in running was associated with lower levels of all measures of body composition in late adolescence and early adulthood. However, these relationships were not independent of body composition in early adolescence, which highlights the importance of achieving and maintaining a healthy weight early in life.

This work was supported by the Canadian Cancer Society (grant nos. 010271 and 017435). J. O. L. holds a Canada Research Chair in the Early Determinants of Adult Chronic Disease, C. S. holds a Canada Research Chair in Physical Activity and Mental Health, and T. B. is a Fonds de recherche du Québec Santé senior research scholar.

The authors declare that they have no conflicts of interest. The results of this study are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation. Results of the present study do not constitute endorsement by the American College of Sports Medicine.

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