Sex Differences in the Association of Youth Body Mass Index to Adult Health-related Quality of Life: The Physical Activity Longitudinal Study

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ABSTRACT

Objective: The long-term consequences of youth overweight on adult health-related quality of life (HRQL) have not been documented. This study examines sex differences in the association between youth body mass index (BMI) and adult HRQL.

Methods: Subjects included 139 male and 142 female participants aged 7-18 in the 1981 Canada Fitness Survey, followed up in 2002-04. The associations of youth BMI to adult HRQL (SF-36) were examined with bivariate correlations, differences in means and multivariate linear regression analyses.

Results: Bivariate analyses revealed positive associations between youth overweight and mental aspects of adult HRQL in females, and weak negative associations with physical aspects, but no significant associations in males. All overweight male and female youth scored the maximum (100) on Role Emotional (RE). In females, compared to healthy weight youth, overweight youth scored 16.0, 13.4, 12.7, and 10.9 points higher on general health (GH), vitality (VT), mental health (MH), and the mental component score (MCS) in adulthood, respectively; a 1 unit increase in youth BMI led to 1.7, 1.5, and 1.4 point increases in adult VT, MH and MCS scores, respectively. Associations were attenuated with the removal of adult BMI from the models, but remained strong for MH and MCS.

Conclusions: Overweight in youth did not have a significant negative impact on HRQL two decades later; rather, a positive association was found with mental aspects of adult HRQL in females.

Key words: Body mass index; body weight; adolescent obesity; longitudinal studies; mental health; quality of life

La traduction du résumé se trouve à la fin de l'article.

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Obesity leads to increased risk of numerous chronic diseases and conditions, including early mortality;¹ however, almost 60% of Canadian adults and over 1 in 4 young people aged 2-18 years are overweight/obese.²

Health-related quality of life (HRQL) refers to perceived physical and mental health over time.³ Research examining the links between obesity and HRQL in healthy general population samples has only recently begun to evolve. In adults, obesity is often associated with significant impairments in HRQL, with greater impairments associated with greater degrees of obesity, and weight loss leading to improved HRQL.⁴ Yet, some studies have shown a positive association between mental HRQL and weight status.⁵⁻⁷ More limited research exists linking youth obesity to poorer youth HRQL, including effects on self-reported health, self-esteem, and physical and social health and functioning.⁸⁻¹⁰

The long-term effects of youth obesity on adult HRQL are unclear; however, over 90% of pediatricians believe that youth overweight could affect future HRQL.¹¹ In a previous investigation of Canadian youth followed up 2 decades later, we reported that overweight youth had greater odds of scoring at or above the norm on several aspects of HRQL in adulthood, particularly the mental aspects, compared to healthy weight youth.¹² To our knowledge, the study, using dichotomized HRQL outcomes based on Canadian normative values, was the first to explore the potential long-term effects of youth body mass index (BMI) on HRQL in adulthood. The current objectives are to explore the relationship

between youth BMI and adult physical and mental HRQL using continuous HRQL outcomes, examining differences by sex.

METHODS

Sample

Data were from the Physical Activity Longitudinal Study (PALS),¹³ the 22-year follow-up of a 20% subsample of participants ages ≥ 7 from the nationally representative 1981 Canada Fitness Survey (CFS; N=23,397).¹⁴ Detailed information regarding the conceptual design, methods and ethics approval of PALS has previously been

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Conflict of Interest: None to declare.

Table 1. Sample Characteristics at Baseline (1981) and 22-year Follow-up (2002-04) – The Physical Activity Longitudinal Study

Characteristic	Males (N=139)	Females (N=142)
Baseline 1981: Ages 7-18 years	12.7 (3.4)	12.2 (3.5)
BMI: Healthy Weight	91.4%	90.8%
Overweight/Obese*	8.6%	9.2%
PA (kcal/kg/day)	4.9 (5.5)	4.4 (4.9)
PA ≥ 1.5 kcal/kg/day	80.8%	67.0%
PA ≥ 3.0 kcal/kg/day	57.7%	46.4%
Follow-up 2002-2004: Ages 29-41 years	35.4 (3.4)	34.9 (3.6)
BMI (kg/m ²)	26.0 (3.4)	25.3 (5.2)
Underweight (<18.5)	1.4%	1.5%
Healthy Weight (18.5-24.9)	40.6%	61.2%
Overweight (25.0-29.9)	47.1%	22.4%
Obese (≥ 30.0)	10.9%	14.9%
PA (kcal/kg/day)	4.2 (5.0)	3.0 (3.6)
PA ≥ 1.5 kcal/kg/day	63.7%	60.2%
PA ≥ 3.0 kcal/kg/day	42.0%	31.2%
Current Smoker	19.0%	21.3%
Self-Reported Health: Very Good/Excellent	48.5%	45.1%
Married	71.7%	82.3%
Education: ≥ 1 University Degree	43.1%	43.6%
Total Household Income: $\geq \$60,000$	63.8%	68.5%
Comorbidities: ≥ 1	46.8%	62.0%
Longitudinal BMI change (1981–2002-2004):		
Healthy Weight – Healthy Weight	41.2%	59.1%
Healthy Weight – Overweight/Obese	50.7%	32.6%
Overweight/Obese – Healthy Weight	0.0%	3.0%
Overweight/Obese – Overweight/Obese	8.1%	5.3%

Values are means (SD) or percentages of total sample.

* There is only 1 obese child (F); 12 overweight M, 12 overweight F.

published.¹³ The final sample included 2,511 participants (51.2% of eligible individuals); the subsample for this analysis included 281 individuals (139 males, 142 females) ages 7-18 in 1981, who had BMI data at baseline and HRQL data in 2002-2004 (ages 29-41). This represents 34.4% of the 817 participants aged 7-18 at baseline.

Measures

Baseline height and weight were measured in 1981. At follow-up (2002-04), all data were self-reported via questionnaire. BMI was calculated as weight (kg)/height (m²). Youth overweight and obesity were categorized according to the International Obesity Task Force (IOTF) age- and gender-specific cut-offs,¹⁵ associated with the predicted WHO-defined adult BMI cut-offs of 25 (overweight) and 30 (obese) kg/m² at age 18.¹⁶

Multidimensional HRQL was assessed using the self-administered Medical Outcomes Study Short Form 36 (SF-36), comprised of 36 questions, assessing 8 physical and mental health domains: physical function (PF), role physical (RP), bodily pain (BP), general health perceptions (GH), vitality (VT), social functioning (SF), role emotional (RE) and mental health (MH).¹⁷ Scores range from 0-100, with higher scores representing better health and less pain. Domains are also weighted and summed to calculate physical and mental component summaries (PCS and MCS), standardized to a mean of 50, with scores above and below 50 representing better and worse than average function, respectively.¹⁸ A 5-point difference (domain scores) and 2-3 point difference (summary scores) are considered clinically relevant.^{17,18}

Statistical analysis

The distributions of 5 of 8 SF-36 outcomes were negatively skewed, with many participants achieving the maximum score of 100 on the 8 domains: GH, VT and MH appeared normally distributed, and

Table 2. Spearman Correlations Between Youth BMI[†] (1981) and Adult SF-36 Scores (2002-04) – The Physical Activity Longitudinal Study

SF-36	Male (n=139)		Female (n=142)	
	r	p-value	r	p-value
PF	-0.02	0.784	-0.03	0.777
RP	0.06	0.507	-0.08	0.355
BP	0.09	0.320	-0.09	0.301
GH	-0.02	0.815	-0.08	0.339
VT	-0.07	0.409	0.14	0.090
SF	0.00	0.976	0.14	0.095
RE	0.10	0.231	0.19*	0.031
MH	0.09	0.319	0.22**	0.008
PCS	-0.04	0.647	-0.21*	0.013
MCS	0.02	0.781	0.26**	0.002

[†] Age-adjusted residuals from regression of BMI on Age.

PF=physical functioning; RP=role physical; BP=bodily pain; GH=general health; VT=vitality; SF=social functioning; RE=role emotional; MH=mental health; PCS=physical component summary; MCS=mental component summary

* p<0.05, **p<0.01.

Figure 1. Mean (95% CI) adult SF-36 scores (2002-04) by youth weight status (1981) – The Physical Activity Longitudinal Study: (a) Males; (b) Females

PF=physical functioning; RP=role physical; BP=bodily pain; GH=general health; VT=vitality; SF=social functioning; RE=role emotional; MH=mental health; PCS=physical component summary; MCS=mental component summary. Independent samples t-tests for GH, VT, MH; Mann-Whitney U for PF, RP, BP, SF, RE, PCS, MCS; * p<0.05, ** p<0.01 (statistical significance lost following adjustment for multiple comparisons by Holm method).

PCS and MCS deviated only slightly from normal. Spearman correlations between youth BMI (ages 7-18) and adult SF-36 scores were calculated. To account for the effect of age on youth BMI, the latter was regressed on age, and the residuals used in analysis to represent age-adjusted youth BMI. Differences in mean adult SF-36 scores by youth weight status were then assessed by independent samples t-tests and Mann Whitney U tests, adjusted for multiple comparisons (Holm method). Linear regression analysis was performed for GH, VT, MH, PCS and MCS. Initially, the association

Table 3. Adjusted Linear Regression of Adult SF-36 Outcomes (2002-04) on Youth BMI (1981) – The Physical Activity Longitudinal Study – Males

SF-36 Outcome	(A) β (95% CI)	p-value	(B) β (95% CI)	p-value
a) Youth BMI (Overweight/Obese vs. Healthy Weight)				
GH	2.7 (-9.0, 14.3)	0.650	5.4 (-6.3, 17.1)	0.362
VT	-3.4 (-16.4, 9.5)	0.602	-1.8 (-15.0, 11.5)	0.791
MH	7.1 (-4.0, 18.3)	0.210	7.3 (-4.3, 18.8)	0.214
PCS	-1.5 (-7.0, 4.0)	0.599	0.3 (-5.2, 5.7)	0.924
MCS	5.0 (-2.8, 12.7)	0.604	4.7 (-3.3, 12.6)	0.246
b) Youth BMI (Continuous)				
GH	0.0 (-1.5, 1.5)	0.987	0.5 (-1.1, 2.1)	0.517
VT	-0.8 (-2.5, 0.8)	0.319	-0.6 (-2.3, 1.2)	0.518
MH	0.5 (-1.0, 2.0)	0.503	0.5 (-1.0, 2.1)	0.515
PCS	-0.1 (-0.8, 0.6)	0.743	0.2 (-0.5, 1.0)	0.525
MCS	0.4 (-0.6, 1.4)	0.466	0.3 (-0.8, 1.4)	0.571

GH=general health; VT=vitality; MH=mental health; PCS=physical component summary; MCS=mental component summary.

"A" models adjusted for age, adult physical activity, household income, education, married, current smoker, # comorbidities; "B" models adjusted for adult BMI, in addition to previous factors.

between adult BMI and the SF-36 outcomes was assessed; youth BMI was then tested both as a continuous and dichotomous predictor. Models were adjusted for age, adult BMI and physical activity, marital and smoking status, education level (university degree), household income ($</\geq \$60,000$), and number of comorbidities (0-7). All analyses were performed separately for males and females.

RESULTS

Descriptive characteristics of the study participants are reported in Table 1. At baseline, approximately 9% of participants were overweight (12 male, 12 female) or obese (1 female); 22 years later, approximately 58% of males and 37% of females were classified as overweight/obese. Over 80% of overweight youth remained overweight/obese as adults, while about 36% of healthy weight youth became overweight/obese.

In females, youth BMI was significantly negatively correlated with PCS, and significantly positively correlated with RE, MH and MCS (Table 2). No significant correlations existed for males.

Figure 1 (a & b) illustrates the mean SF-36 scores by sex for healthy weight vs. overweight/obese youth. Both male and female overweight youth scored higher on RE (all scored the maximum of 100), and overweight females scored higher on MH and MCS, compared to their healthy weight counterparts; however, these differences did not remain statistically significant following adjustment for multiple comparisons.

An initial adjusted regression analysis assessed the association of adult BMI with the 5 normally distributed SF-36 scores. Overweight/obese males scored significantly lower on PCS ($p<0.01$) and overweight/obese females scored significantly lower on GH ($p<0.05$) compared to their healthy weight adult counterparts (data not shown).

Tables 3 and 4 show the linear regression results, by sex, for youth BMI and adult SF-36 scores, with and without adjustment for adult BMI. No significant predictions were observed in the male participants (Table 3). Prior to adjustment for adult BMI, overweight/obese female youth scored 10 points higher on both VT and MH and 9.1 points higher on MCS in adulthood, compared to healthy weight female youth (Table 4a, Models A), and a 1 unit increase in youth BMI led to 1.2 and 1.1 point increases in adult MH and MCS, respectively (Table 4b, Models A). After adjustment

Table 4. Adjusted Linear Regression of Adult SF-36 Outcomes (2002-04) on Youth BMI (1981) – The Physical Activity Longitudinal Study – Females

SF-36 Outcome	(A) β (95% CI)	p-value	(B) β (95% CI)	p-value
a) Youth BMI (Overweight/Obese vs. Healthy Weight)				
GH	9.4 (-1.8, 20.5)	0.098	16.0 (3.7, 28.4)	0.011
VT	10.0 (0.4, 19.5)	0.041	13.4 (2.8, 24.1)	0.014
MH	10.0 (1.0, 19.0)	0.029	12.7 (2.6, 22.8)	0.014
PCS	1.6 (-3.6, 6.7)	0.604	2.4 (-3.5, 8.3)	0.429
MCS	9.1 (2.2, 16.0)	0.010	10.9 (3.0, 18.8)	0.007
b) Youth BMI (Continuous)				
GH	0.1 (-1.3, 1.4)	0.929	1.2 (-0.5, 2.8)	0.162
VT	0.8 (-0.4, 2.0)	0.173	1.7 (0.3, 3.1)	0.017
MH	1.2 (0.2, 2.3)	0.027	1.5 (0.2, 2.8)	0.024
PCS	-0.3 (-0.9, 0.3)	0.290	-0.3 (-1.1, 0.4)	0.396
MCS	1.1 (0.3, 1.9)	0.010	1.4 (0.4, 2.4)	0.008

GH=general health; VT=vitality; MH=mental health; PCS=physical component summary; MCS=mental component summary.

"A" models adjusted for age, adult physical activity, household income, education, married, current smoker, # comorbidities; "B" models adjusted for adult BMI, in addition to previous factors.

for adult BMI, on average, overweight/obese female youth scored 16, 13.4, and 12.7 points higher on GH, VT and MH in adulthood, respectively, and 10.9 points higher on MCS, compared to healthy weight female youth (Table 4a, Models B); a 1 unit increase in youth BMI led to 1.7, 1.5 and 1.4 point increases in adult VT, MH and MCS, respectively (Table 4b, Models B).

DISCUSSION

To our knowledge, the PALS study is the first to examine the long-term effects of youth overweight on adult HRQL. Building on earlier findings,¹² we found significant positive associations between youth BMI and subsequent adult HRQL 22 years later in females, but no association in males. Past research has shown that youth overweight/obesity can affect physical growth and development into adulthood,¹⁹ and is linked to worse self-reported health,⁹ increased likelihood of physical limitations,^{8,9} decreased psychosocial functioning and self-esteem,^{8,20} and increased incidence of bullying.²¹ However, we found no long-term negative implications on adult HRQL, at least at moderate levels of youth overweight.

In a previous analysis comparing the PALS sample against Canadian SF-36 normative values, overweight youth were more likely than healthy weight youth to score at/above the norm on both MH and MCS, with positive associations also found for GH, SF and RE; however, results for GH in particular implicated adult BMI in a moderating role, with the relative increase in BMI from youth to adulthood likely the key factor involved, rather than youth BMI itself exerting an independent effect.¹²

In the present sex-stratified analysis, a higher youth BMI predicted higher absolute scores on RE, VT, MH and MCS in adulthood, but only in females. Regression results are presented both with and without adjustment for adult BMI, for reasons discussed at length previously.¹² Briefly, as this variable may not be a true confounder^{22,23} but may instead (or also) be a moderator in the pathway from youth BMI to adult HRQL, the reversal paradox may be invoked whereby the association between two variables can be reversed or enhanced when another variable is statistically controlled.^{23,24} Indeed, the relationship of youth BMI with GH in females became significant only upon inclusion of adult BMI in the regression model. This inclusion also somewhat strengthened the positive relationship of youth BMI to VT, MH and MCS. As adult

BMI was also found to be a significant negative predictor of GH, it is likely that the relationships may be partly (VT, MH and MCS) or completely (GH) due to the relative change in BMI from youth to adulthood, rather than to a purely independent effect of youth BMI on adult HRQL.¹²

In adults, several studies have reported that overweight and obesity were related to poorer physically oriented SF-36 outcomes.^{5,6,25-28} In this analysis, current adult BMI was a significant negative predictor of GH (females) and PCS (males) only. While tracking of BMI in the PALS sample is high, with over 80% of overweight youth becoming overweight/obese adults, the majority of overweight/obese adults were not overweight in their youth.²⁹ Thus, current adult weight status may be more important to physical HRQL than past youth weight status.

Previously reported associations of adult obesity with the mentally oriented SF-36 outcomes have been weaker and less clear than those found for the physical domains and PCS,^{6,25,26,28} including some studies which found a positive association between adult obesity and the SF-36 mental domains;^{5-7,27} as such, our findings of a positive association of youth BMI to the adult RE, MH and MCS may not be completely unusual.

While potential sex differences have been identified in previous studies, these have been inconsistent. One study showed that obese men ages 16-34 were more likely to rate both their physical and mental HRQL lower than healthy weight men, compared to women who did not report worse mental HRQL.²⁸ Another found that after controlling for physical ill-health, overweight and obesity were associated with better mental health in women, but not in men.⁷ Another reported that while both obese men and women showed worse physical functioning than healthy weight persons, obesity was associated with better mental HRQL in males only.⁵

As very few overweight youth became healthy weight adults (Table 1), relative "weight loss" over time is unlikely to be driving the positive association of youth overweight with adult mental HRQL in females. In a previous analysis of longitudinal BMI status change, PALS participants who were overweight/obese both as youth and adults had significantly greater odds of scoring at/above the norm on both MH and MCS, while relative "weight gain" over time led to decreased odds of scoring at/above the norm on GH.¹² As well, in a logistic regression stratified by adult BMI categories, youth BMI appeared to be a significant positive predictor of scoring at/above the norm on RE, MH and MCS in both healthy weight and overweight/obese adults.¹² The present analysis confirms a positive association of youth BMI to adult mental HRQL in terms of absolute scores in females, which seems at least partly independent of adult BMI or the change in weight between the two time points.

The main strengths of this research are the 22-year length of follow-up from childhood into adulthood in a representative Canadian population sample, the use of measured BMI data at baseline, and the use of the valid and widely-accepted SF-36 instrument.

Study limitations include the small sample size and high attrition, a common problem in longitudinal studies spanning several decades. BMI as a measure of overweight is inherently limited in its lack of information regarding body composition, and lack of sensitivity to youth maturational age; however, it remains the most widely investigated and easily used indicator of weight-related health risk on a population level. Moreover, the effects of age and maturation were diminished by our use of IOTF cut-offs for youth

BMI categorization, age-adjusting youth BMI to examine correlations, and adjusting for age in regressions, all within a sex-stratified analysis. Finally, while the prevalence of youth overweight in the PALS sample is representative of Canada in 1981, the low absolute number of overweight/obese youth (only 1 obese child) may have impacted results. As our results are based on a primarily healthy weight sample, caution should be used when extrapolating findings to overweight/obese groups due to the small sample in these groups. The prevalence of youth overweight/obesity has nearly tripled since that time,² which may yet lead to negative consequences on HRQL over the long term.

In conclusion, these results suggest that moderate levels of youth overweight may not lead to increased risk of poorer HRQL in adulthood, and may be associated with better mentally-oriented HRQL in females. However, as youth overweight has known immediate health consequences,¹⁹ and tracks strongly into adulthood,²⁹ where it is associated with substantially increased risk of a host of other biomedical conditions,¹ it is not an issue that can be ignored. It is also possible that greater and more negative HRQL consequences might result from the higher degrees of youth obesity present in today's population. More research is needed on larger cohorts with a higher prevalence and degree of youth obesity to further assess the long-term impact on physical and mental health, including further exploration of sex differences, possible critical age ranges, and the role of BMI status changes over time.

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RÉSUMÉ

Objectifs : Les conséquences à long terme du surpoids durant l'enfance sur la qualité de vie liée à la santé (QVLS) à l'âge adulte n'ont pas été étudiées. Nous examinons ici l'écart entre les sexes dans l'association entre l'indice de masse corporelle (IMC) durant l'enfance et la QVLS à l'âge adulte.

Méthode : Nos sujets étaient 139 garçons et 142 filles de 7 à 18 ans ayant participé à l'Enquête condition physique Canada en 1981 et fait l'objet de suivis en 2002-2004. Nous avons étudié les associations entre l'IMC durant l'enfance et la QVLS à l'âge adulte (selon le questionnaire SF-36) à l'aide de corrélations bivariées, de différences dans les moyennes et de régressions linéaires multivariées.

Résultats : Les analyses bivariées ont mis au jour des associations positives entre le surpoids durant l'enfance et les aspects mentaux de la QVLS à l'âge adulte chez les femmes, ainsi que de faibles associations négatives avec les aspects physiques, mais aucune association significative chez les hommes. Tous les enfants en surpoids, garçons et filles, ont obtenu le score maximal (100) à l'égard des « limitations du rôle liées à la santé mentale » (RE). Chez les filles, comparativement aux enfants ayant un poids-santé, les enfants en surpoids ont obtenu 16,0, 13,4, 12,7 et 10,9 points de plus, respectivement, pour la santé générale (GH), la vitalité (VT), la santé mentale (MH) et le score mental (MCS) à l'âge adulte; une augmentation d'1 unité dans l'IMC durant l'enfance correspondait à des augmentations de 1,7, 1,5 et 1,4 points dans les indices VT, MH et MCS à l'âge adulte, respectivement. Ces associations étaient atténuées lorsqu'on retirait des modèles l'IMC à l'âge adulte, mais elle demeurait forte pour la santé mentale et le score mental.

Conclusion : Nous n'avons pas observé d'incidence négative significative du surpoids durant l'enfance sur la QVLS 20 ans plus tard; au lieu de cela, nous avons observé une association positive avec les aspects mentaux de la QVLS à l'âge adulte chez les filles.

Mots clés : indice de masse corporelle; poids; obésité adolescente; études longitudinales; santé mentale; qualité de vie

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Food safety is particularly important for people in specific higher-risk groups that are more vulnerable to germs that are sometimes carried in our food.

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The production of this resource targeted at higher-risk groups, their caregivers and the broader Canadian population was made possible through an unrestricted educational grant from Maple Leaf Foods Inc.

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