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A cross-sectional analysis of physical activity and weight misreporting in diverse populations: The Seattle Obesity Study III

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Summary

Background: In-person assessments of physical activity (PA) and body weight can be burdensome for participants and cost prohibitive for researchers. This study examined self-reported PA and weight accuracy and identified patterns of misreporting in a diverse sample.

Methods: King, Pierce and Yakima county residents, aged 21–59 years (n = 728), self-reported their moderate-to-vigorous PA (MVPA) and weight, in kilograms. Self-reports were compared with minutes of bout-level MVPA, from 3 days of accelerometer data, and measured weights. Regression models examined characteristics associated with underreporting and overreporting of MVPA and weight, the potential bias introduced using each measure and the relation between perceived and measured PA and weight.

Results: MVPA underreporting was higher among males and college educated participants; however, there was no differential MVPA overreporting. Weight underreporting was higher among males, those age 40–49 years and persons with obesity. Weight overreporting was higher among Hispanic participants and those reporting stress, unhappiness and fair or poor health. The estimated PA–obesity relation was similar using measured and self-reported PA but not self-reported weight. Perceived PA and weight predicted measured values.

Conclusion: Self-reported PA and weight may be useful should objective measurement be infeasible; however, though population-specific adjustment for differential reporting should be considered.

KEYWORDS

Health disparity, obesity, physical activity, self-reported outcomes

Abbreviations: BMI, body mass index; CI, confidence interval; MVPA, moderate-to-vigorous physical activity; PA, physical activity; PR, prevalence ratio; SD, standard deviation.

1 | INTRODUCTION

Physical activity (PA) has long been identified as important determinant of body weight and obesity risk.[1] Yet the strength and magnitude of this relation can vary markedly based on the method by which PA and obesity are assessed. Although accuracy in the collection of these metrics is critical, methods such as the use of wearable accelerometers to capture PA and in-person measurement of height and weight to evaluate obesity can be resource intensive for researchers and burdensome for participants.[2,3] Increasingly, researchers are relying on self-reported data collected via telephone surveys,[4,5] smartphone apps[6,7] or the web. Such data collection methods are relatively inexpensive and easily scalable for use in large longitudinal studies or in population-based, cross-sectional assessments. Yet these self-reports are often prone to misreporting stemming from lack of knowledge, imperfect recall and a variety of differential biases, some driven by social desirability and other demographic and sociocultural factors.[8–17] In general, people tend to overestimate their PA and underestimate their weight.[8–17] An extensive literature has explored the reasons for underreporting and overreporting and has identified the likely sources of a differential response bias.[8–17]

Wearable accelerometers are a standard method for the collection of objective of PA.[18] PA self-reporting tools such as the International Physical Activity Questionnaire ask about the frequency, duration and intensity of typical PA sessions or bouts.[2] Data from such tools tend to overestimate actual PA effort.[8,11,17] Further, PA overreporting has been observed to be higher among men and persons with lower education.[8,11,17] Other differential biases in PA reporting have included age and the degree of overweight.[19,20]

Measured heights and weights, which are employed in some surveys such as the National Health and Nutrition Examination surveys, are the preferred way to calculate body mass index (BMI).[21] However, other surveys, such as Behavioral Risk Factor Surveillance System, rely on self-reported anthropometrics.[22] In general, people overreport their height and underreport their weight, leading to biased BMI values.[3,21,23–26] The magnitude of this bias has been found to vary by gender, age, race/ethnicity and obesity status.[3,21,23–26] There is also evidence that weight misreporting may be influenced by mental well-being (e.g., stress and depression).[27] Despite these patterns of discrepancy, some studies have found good correspondence between reported and measured weights.[25,27]

The literature on the likely causes of misreporting has focused on a relatively narrow range of demographic factors and/or obesity status.[8–16,27] Fewer studies have explored the potential role of mental well-being.[10,23,27,28] There is also evidence to suggest that the extent of misreporting and bias may differ across population subgroups.[3,20,26,29] Most germane to the present work are recent studies that have found that misreporting patterns differ in Hispanic and low-income populations.[3,20,26,29]

This study sought to examine patterns of potential misreporting of PA and body weight in a racially and socioeconomically diverse sample. First, this study aimed to identify key sociodemographic, health and mental well-being factors that were associated with underreporting or overreporting in this population. Second, this study explored whether, and how strongly, perceived measures of PA and weight were related to measured PA and body weight.

2 | METHODS

2.1 | Study population

The Seattle Obesity Study (SOS) III recruited 872 participants from King, Pierce and Yakima counties in Washington State (WA) using a stratified addressed-based sampling scheme. Study sites were the University of Washington (King County), MultiCare Institute for Research and Innovation (Pierce County) and the Fred Hutchinson Cancer Research Center (Yakima County). King County participants were sampled based on three strata of residential property values.[30] The Pierce County sampling frame included five strata based on distance from the MultiCare site and median household income at the U.S. Census ZIP code tabulation area level. Pierce County participants were sampled from the MultiCare employee and primary care database, with low-income participants recruited through community outreach. Yakima County participants were recruited from the Fred Hutch participant pool and through community outreach. Eligibility criteria across all sites included being (1) the primary food shopper in their household, (2) age 21 to 59 years, (3) not pregnant or breastfeeding, (4) without physical mobility restrictions or issues and (5) English or Spanish speaking. Recruitment at each site was done through a combination of telephone calls, letters and community outreach. This recruitment strategy yielded a unique and diverse sample that spanned a range of education and property values and included a high proportion of rural Hispanics (Yakima County). A full description of participant recruitment and enrolment can be found in Figure A1.

2.2 | Self-reported, perceived and measured PA

Participants self-reported whether their weekly PA met the 2018 Centers for Disease Control and Prevention (CDC) guidelines for PA for Americans[31] of 2.5 h week^{-1} using the question: 'In an average week, do you exercise at least 2.5 hours per week?' where participants could respond yes or no. All participants also wore Actigraph accelerometers for three consecutive days on weekdays or weekends for at least 10 h day^{-1} to provide objectively measured PA data. PA bout identification was operationalized using the 'accelerometry' R package.[32] To delineate PA levels from the count per minute (cpm) data provided by the accelerometers, the following cut points were used: sedentary (<100 cpm), sedentary-to-low (<2690 cpm), moderate (2690–6166 cpm), vigorous (6167–9642 cpm) and very vigorous (>9642 cpm).[33] The moderate to very vigorous categories were aggregated into a single 'moderate-to-vigorous' category. Sustained bouts of moderate-to-vigorous PA (MVPA) were identified as having a duration of at least 8 min within the 2690–9642 cpm range or 10 min allowing for up to 2 min between 0 and 100 cpm (known as 'modified

10-min' bouts). To calculate weekly MVPA, total time spent in MVPA was divided by 3, the number of days of accelerometer measurement, and multiplied by 7. Participants were classified as having met the ≥2.5 h week^{-1} guideline of MVPA guideline or not.[34] To capture perceived PA level, participants were asked, 'Do you consider yourself physically active?' where participants could respond yes or no.

2.3 | Self-reported, measured and perceived anthropometrics

Participants were asked to first report their height and weight; then, these measures were taken by trained staff using calibrated scales and stadiometers. Heights were then converted to meters, and weights were converted to kilograms. As part of their consent, all participants were made aware that they would need to provide both self-reported and measured anthropometrics. To capture perceived weight status, participants were asked 'In your opinion, are you now …?' to which participants could answer 'very underweight', 'somewhat underweight', 'about the right weight', 'somewhat overweight' and 'very overweight'. Few participants answered that they were 'very underweight' or 'somewhat underweight'; therefore, these categories were combined with the 'about the right weight' category for analytic purposes.

2.4 | Accurate reporting, underreporting and overreporting

PA and weight underreporting and overreporting were defined by the bidirectional mismatch between self-reported and measured PA and weight values and were compared with accurate reporters. Accurate PA reporting was defined as agreement between self-reported MVPA and accelerometer MVPA, such that both metrics classified the individual as meeting the PA guidelines or not. PA underreporting was defined as self-reporting that one did not meet PA guidelines but had accelerometer values that indicated that they performed ≥2.5 h of MVPA per week. PA overreporting was as defined as self-reporting that one did meet the PA guidelines but had accelerometer values that indicated <2.5 h of MVPA per week. For weight, accurate reporting was defined as self-reporting a weight that was within 1 kg of the scale-measured weight. Weight underreporting was defined as self-reporting a weight was >1 kg below the measured weight value. Weight overreporting was defined as self-reporting a weight was >1 kg above the measured weight value.

2.5 | Sociodemographic, health and mental well-being characteristics

Several sociodemographic factors as well as health and mental well-being measurements were included in this analysis. Sociodemographic variables included age (21 to 39, 40 to 49 and ≥50 years), gender (male or female), race/ethnicity (White, Hispanic and other), marital status (unmarried/single/divorced or married), educational attainment (high school education or less, some college and college or grad/grad school) and employment status (employed, unemployed or not in labour force). Note that, in this study, 'Hispanic' was also included as a race category, in addition to being included as an ethnicity category, to be culturally sensitive to the largely Hispanic population of Yakima who self-identified as Hispanic as both a race and ethnicity. Health and mental well-being measured included CDC BMI categories, based on measured height and weight data (underweight or normal weight, overweight or obese), self-reported health (poor, fair, good, very good and excellent), self-reported physician-diagnosed depressive disorder (yes or no), frequency of stress in the past 30 days (all the time, most of the time, some of the time, a little of the time or not at all) and frequency of happiness generally (all the time, most of the time some of the time, a little of the time or not at all).

2.6 | Statistical analysis

SOS participants with complete sociodemographic, health and mental well-being data as well as complete self-reported, measured and perceived PA and weight data were included in this analysis. A total of 144 participants with missing information were removed. This left 728 (83%) participants of the 872 surveyed at baseline included in the final analytic sample. Most of the 144 participants (n = 105) were excluded due to missing self-reported anthropometric information these values were unknown, or the participant declined to provide it. A comparison of participants included and excluded from the analysis can be found in Table A1.

For analytic purposes, Likert scales for health and mental well-being were dichotomized. Self-reported health was dichotomized to 'fair or poor' versus 'good, very good or excellent' for self-reported health. Frequency of stress in the past 30 days was dichotomized to 'all or most of the time' versus 'some, a little of the time or not at all'. General happiness was dichotomized to 'some, a little of the time or not at all' versus 'all or most of the time'.

Bivariable modified Poisson regression models using generalized estimating equations (GEE) were conducted, using a complete case analysis to cross-sectionally identify and estimate the prevalence ratio (PR) of factors associated with PA and weight underrreporting or overreporting. We also evaluated joint misreporting patterns of PA and weight. Unadjusted and adjusted modified Poisson regression were also used to estimate the relation between PA and obesity under four scenarios: model 1: accelerometer-derived PA and measured obesity (calculated using measured heights and weights), model 2: self-reported PA and measured obesity, model 3: accelerometer-derived PA and self-reported obesity (calculated using self-reported heights and weights) and model 4: self-reported PA and self-reported obesity. These models allowed us to descriptively examine the change in model estimates associated with using self-reported versus objective metrics. Unadjusted and adjusted multivariable linear regression models were run to estimate the predictability of perceived weight

TABLE 1 Sample sociodemographic, health and mental well-being characteristics Seattle Obesity Study (SOS) III (n = 728)

Characteristics	*n*	%
Age		
21–39 years	233	32.0
40–49 years	211	30.0
≥50 years	284	39.0
Gender		
Female	592	81.3
Male	136	18.7
Race/ethnicity		
White	382	52.5
Hispanic	254	34.9
Other (Black, Asian, etc.)	92	12.6
Marital status		
Unmarried/single/divorced	312	42.9
Married	416	57.1
Education		
High school or less	209	28.7
Some college	168	23.1
College graduate/graduate school	251	48.2
Employment		
Employed	544	74.7
Unemployed or not in labour force	184	25.3
Body mass index categories		
Underweight or normal weight	205	28.2
Overweight	219	30.1
Obese	304	41.8
Self-reported health		
Good, very good or excellent	565	77.6
Fair or poor	163	22.4
Depression		
No	556	76.4
Yes	172	23.6
Stressed (past 30 days)		
Some, a little of the time or not at all	592	81.3
All or most of the time	136	18.7
General happiness		
All or most of the time	542	74.5
Some, a little of the time or not at all	186	25.6

Note: Category 'Hispanic' was included as both a race and ethnicity category. *n* = sample size.

status and measured weight as well as perceived PA and measured MVPA. Adjustment included all aforementioned sociodemographic, health and mental well-being factors evaluated for misreporting. Additionally, adjusted models were controlled for county to account for the different recruitment strategies across sites. All regression models used robust standard errors. Tests were two-sided using an α level of 0.05. Analyses were used Stata version 14.[35]

3 | RESULTS

Participants were predominately aged 50 years or more (39.0%) and married (57.1%) (Table 1). Approximately 34.9% of the sample identified as Hispanic whereas 12.6% identified as some other race (non-Hispanic Black, non-Hispanic Asian, Alaska Native, among others). Half of participants (51.8%) did not complete college. Few participants were male (18.7%) or unemployed or not in the labour force (25.3%). Approximately 30.1% of participants had a measured BMI that classified them as overweight whereas another 41.8% had a BMI that classified them as obese. About 22.4% of participants self-reported their health as fair or poor. For mental well-being, 23.6% of participants reported depression, 18.7% reported frequent stress and 25.6% reported infrequent happiness. With respect to the accuracy of PA reporting in the overall sample, 60.3% of participants accurately reported their PA with 6.0% underreporting and 33.7% overreporting. Approximately 43.6% of participants self-reported their weight accurately within 1 kg whereas 46.4% underreported and 10.0% overreported their weight by >1 kg.

Table 2 provides the percentage of participants meeting PA guidelines using self-reported versus measured PA data as well as bivariate analysis of underreporting and overreporting of PA by several characteristics. Overall, 58.1% of the participants reported that they met the CDC PA guidelines of ≥2.5 h of MVPA per week compared with 30.4% according to accelerometer-captured PA. Among those who reported that met MVPA guidelines, 42.1% did so accurately whereas among those who reported not meeting guidelines, 85.9% did so accurately (Table A2). Across all characteristics examined, the percentage of participants that self-reported meeting PA guidelines was approximately twofold higher than the percentage classified as meeting the guidelines based on accelerometer-measured PA. Males had a differentially higher prevalence of PA underreporting compared with females (PR = 2.10, 95% CI = 1.17, 3.79). Those with some college education (PR = 0.41, 95% CI = 0.17, 0.99) had a lower prevalence of PA underreporting compared with those with a high school education or less. No characteristics were differentially associated with a higher or lower prevalence of PA overreporting.

Table 3 provides self-reported versus measured mean weight as well as bivariate analysis of underreporting and overreporting. Mean self-reported weight was 79.8 kg (SD = 20.0) and was similar to the measured weight of 81.1 kg (SD = 20.5). Mean self-reported weight was consistently lower than mean measured weight but were comparable (within 1 to 2 kg), across nearly all characteristics. Participants who were age 40–49 years (PR = 1.32, 95% CI = 1.09, 1.60), were male (PR = 1.27, 95% CI = 1.07, 1.49) and with overweight (PR = 1.28, 95% CI = 1.01, 1.61) or obesity (PR = 1.58, 95% CI = 1.29, 1.94) had a greater prevalence of weight underreporting. Conversely, those participants reporting other races (PR = 0.80, 95% CI = 0.69, 0.93) and those who were married (PR = 0.80, 95 CI = 0.69, 0.93) had a lower prevalence of weight underreporting. Participants who were Hispanic (PR = 1.82, 95% CI = 1.17, 2.81), reported fair or poor health (PR = 1.76, 95% CI = 1.16, 2.66), were frequently stressed (PR = 1.62, 95% CI = 1.04, 2.52) or infrequently happy (PR = 1.64, 95% CI = 1.08,

TABLE 2 Reported, measured, underreporting and overreporting physical activity by sociodemographic, health and mental well-being characteristics (n = 728)

	Met PA guidelines					
	Reported	Measured	Underreport vs. accurate		Overreport vs. accurate	
Characteristics	%	%	PR	(95% CI)	PR	(95% CI)
Overall	58.1	30.4	—	—	—	—
Age						
21–39 years	54.1	29.2	1.00	—	1.00	—
40–49 years	54.5	29.4	0.88	(0.42, 1.81)	0.98	(0.74, 1.28)
≥50 years	64.1	32.0	0.96	(0.49, 1.89)	1.19	(0.94, 1.51)
Gender						
Female	56.8	26.5	1.00	—	1.00	—
Male	64.0	47.1	2.10*	(1.17, 3.79)	0.86	(0.64, 1.14)
Race/ethnicity						
White	68.6	37.7	1.00	—	1.00	—
Hispanic	41.7	19.3	1.46	(0.79, 2.70)	0.87	(0.69, 1.09)
Other (Black, Asian, etc.)	59.8	30.4	1.39	(0.58, 3.35)	1.03	(0.76, 1.39)
Marital status						
Unmarried/single/divorced	55.1	31.7	1.00	—	1.00	—
Married	60.3	29.3	0.78	(0.44, 1.38)	1.16	(0.94, 1.43)
Education						
High school or less	43.5	21.1	1.00	—	1.00	—
Some college	56.6	25.6	0.41*	(0.17, 0.99)	1.03	(0.78, 1.37)
College graduate/grad school	67.5	38.2	0.59	(0.32, 1.09)	1.05	(0.82, 1.33)
Employment						
Employed	60.7	31.1	1.00	—	1.00	—
Unemployed or not in labour force	50.5	28.3	1.04	(0.55, 1.96)	0.82	(0.64, 1.06)
Body mass index categories						
Underweight or normal weight	72.2	40.0	1.00	—	1.00	—
Overweight	61.2	33.8	1.18	(0.51, 2.71)	0.91	(0.70, 1.18)
Obese	46.4	21.4	1.54	(0.73, 3.24)	0.91	(0.71, 1.15)
Self-reported health						
Good, very good or excellent	63.2	34.0	1.00	—	1.00	—
Fair or poor	40.5	17.8	0.96	(0.49, 1.89)	0.83	(0.63, 1.07)
Depression						
No	59.4	30.2	1.00	—	1.00	—
Yes	54.1	30.8	1.03	(0.53, 1.98)	0.86	(0.66, 1.10)
Stressed (past 30 days)						
Some, a little of the time or not at all	62.0	33.3	1.00	—	1.00	—
All or most of the time	42.2	17.7	0.64	(0.28, 1.47)	0.78	(0.59, 1.05)
General happiness						
All or most of the time	60.7	31.4	1.00	—	1.00	—
Some, a little of the time or not at all	50.5	27.4	0.80	(0.40, 1.57)	0.80	(0.62, 1.03)

Note: Percentage values are row percentages. Accurate PA reporting was defined as agreement between self-reported and accelerometer MVPA such that both metrics classified the individual as meeting the PA guidelines or classified the individual or not. PA underreporting was defined as self-reporting that one did not meet PA guidelines but had accelerometer values that indicated that they performed ≥2.5 h of MVPA per week. PA overreporting was as defined as self-reporting that one did meet the PA guidelines but had accelerometer values that indicated <2.5 h of MVPA per week.

Abbreviations: CI, confidence interval; MVPA, moderate-to-vigorous physical activity; PA, physical activity; PR, prevalence ratio.

*$P < 0.05$.

TABLE 3 Reported, measured, underreporting and overreporting weight (kg) by key characteristics (n = 728)

	Weight (kg)					
	Reported	Measured	Underreport vs. accurate		Overreport vs. accurate	
Characteristics	Mean (SD)	Mean (SD)	PR	(95% CI)	PR	(95% CI)
Overall	79.8 (20.0)	81.1 (20.5)	—	—	—	—
Age						
21–39 years	79.2 (20.7)	80.4 (21.2)	1.00	—	1.00	—
40–49 years	80.0 (20.6)	81.6 (21.5)	1.32**	(1.09, 1.60)	1.01	(0.61, 1.67)
≥50 years	80.1 (19.1)	81.3 (19.0)	1.09	(0.90, 1.32)	0.80	(050, 1.30)
Gender						
Female	78.0 (20.0)	79.2 (20.4)	1.00	—	1.00	—
Male	87.9 (18.2)	89.2 (18.6)	1.27**	(1.07, 1.49)	1.56	(0.98, 2.49)
Race/ethnicity						
White	80.6 (20.1)	81.9 (20.4)	1.00	—	1.00	—
Hispanic	78.7 (18.2)	80.2 (18.9)	0.96	(0.81, 1.12)	1.82**	(1.17, 2.81)
Other (Black, Asian, etc.)	79.4 (24.1)	80.4 (24.5)	0.71*	(0.53, 0.95)	1.02	(0.51, 2.04)
Marital status						
Unmarried/single/divorced	81.2 (20.5)	82.6 (21.0)	1.00	—	1.00	—
Married	78.8 (19.6)	80.0 (20.0)	0.80**	(0.69, 0.93)	0.47***	(0.31, 0.70)
Education						
High school or less	80.0 (20.0)	81.8 (20.8)	1.00	—	1.00	—
Some college	82.3 (21.5)	83.3 (21.6)	0.83	(0.66, 1.03)	0.70	(0.42, 1.16)
College graduate/grad school	78.5 (19.3)	79.7 (19.6)	0.94	(0.79, 1.11)	0.52**	(0.33, 0.84)
Employment						
Employed	79.3 (20.1)	80.5 (20.5)	1.00	—	1.00	—
Unemployed or not in labour force	81.3 (19.8)	82.7 (20.3)	0.88	(0.73, 1.07)	1.36	(0.89, 2.07)
Measured body mass index categories						
Underweight or normal weight	62.1 (8.3)	62.7 (8.4)	1.00	—	1.00	—
Overweight	74.3 (9.9)	75.2 (9.9)	1.28*	(1.01, 1.61)	1.06	(0.61, 1.82)
Obese	95.7 (18.9)	97.8 (18.8)	1.58***	(1.29, 1.94)	1.42	(0.87, 2.32)
Self-reported health						
Good, very good or excellent	76.6 (17.8)	77.9 (18.3)	1.00	—	1.00	—
Fair or poor	91.0 (23.0)	92.3 (23.4)	1.03	(0.86, 1.23)	1.76**	(1.16, 2.66)
Depression						
No	78.1 (19.3)	79.5 (20.0)	1.00	—	1.00	—
Yes	85.4 (21.3)	86.4 (21.1)	1.05	(0.88, 1.24)	1.06	(0.66, 1.70)
Stressed (past 30 days)						
Some, a little of the time or not at all	78.7 (19.4)	80.0 (20.0)	1.00	—	1.00	—
All or most of the time	84.8 (21.8)	86.1 (21.9)	1.09	(0.91, 1.31)	1.62*	(1.04, 2.52)
General happiness						
All or most of the time	79.0 (20.3)	80.4 (20.8)	1.00	—	1.00	—
Some, a little of the time or not at all	82.1 (19.0)	83.2 (19.4)	1.13	(0.96, 1.33)	1.64*	(1.08, 2.48)

Note: Accurate reporting was defined as self-reporting a weight that was within 1 kg of the scale-measured weight. Weight underreporting was defined as self-reporting a weight that was >1 kg below the measured value. Weight overreporting was defined as self-reporting a weight that was >1 kg above the measured value. n = sample size.

Abbreviations: CI, confidence interval; PR, prevalence ratio; SD, standard deviation.

*$P < 0.05$.

**$P < 0.01$.

***$P < 0.001$.

TABLE 4 Joint evaluation of physical activity and weight (kg) misreporting (n = 728)

		Weight											
		Accurate report				Underreport				Overreport			
Physical activity	Total	*n*	%	PR	95% CI	*n*	%	PR	95% CI	*n*	%	PR	95% CI
Accurate report	440	186	42.3	1.00	—	211	48.0	1.00	—	43	9.8	1.00	—
Underreport	43	15	34.9	0.83	(0.54, 1.26)	19	44.2	1.05	(0.77, 1.44)	9	20.9	2.00*	(1.11, 3.58)
Overreport	245	116	47.4	1.12	(0.94, 1.33)	106	43.3	0.90	(0.76, 1.06)	23	9.4	0.88	(0.56, 1.40)
		Physical activity											
		Accurate report				Underreport				Overreport			
Weight	Total	*n*	%	PR	95% CI	*n*	%	PR	95% CI	*n*	%	PR	95% CI
Accurate report	317	186	58.7	1.00	—	15	4.7	1.00	—	116	36.6	1.00	—
Underreport	336	211	62.8	1.07	(0.95, 1.21)	19	5.7	1.11	(0.58, 2.12)	106	31.6	0.87	(0.70, 1.08)
Overreport	75	43	57.3	0.98	(0.79, 1.21)	9	12.0	2.32*	(1.08, 5.00)	23	30.7	0.91	(0.63, 1.30)

Note: Percentage values are row percentages. Accurate PA reporting was defined as agreement between self-reported and accelerometer MVPA such that both metrics classified the individual as meeting the PA guidelines or classified the individual or not. PA underreporting was defined as self-reporting that one did not meet PA guidelines but had accelerometer values that indicated that they performed ≥2.5 h of MVPA per week. PA overreporting was as defined as self-reporting that one did meet the PA guidelines but had accelerometer values that indicated <2.5 h of MVPA per week. Accurate reporting was defined as self-reporting a weight that was within 1 kg of the scale-measured weight. Weight underreporting was defined as self-reporting a weight that was >1 kg below the measured value. Weight overreporting was defined as self-reporting a weight that was >1 kg above the measured value. *n* = sample size.

Abbreviations: CI, confidence interval; MVPA, moderate-to-vigorous physical activity; PA, physical activity; PR, prevalence ratio.

*$P < 0.05$.

2.48) had a higher prevalence of overreporting. Participants who were married (PR = 0.47, 95% CI = 0.31, 0.70) and had a college or graduate degree (PR = 0.52, 95% CI = 0.33, 0.84) had a lower prevalence of weight overreporting.

Table 4 displays the joint evaluation of PA and weight misreporting. In general, there was insufficient evidence support to any patterns of joint underreporting or overreporting of PA and weight relative to accurate reporters. There was some suggestive evidence that those participants who underreported their PA had a higher prevalence of weight overreporting (PR = 2.00, 95% CI = 1.11, 3.58) whereas weight underreporting among those same participants was associated with a higher prevalence of PA underreporting (PR = 2.32, 95% CI = 1.08, 5.00). However, these estimates were imprecise and should be interpreted with caution.

Table 5 shows the relation between PA and obesity under four scenarios using self-reported versus measured metrics unadjusted and adjusted for factors related to misreporting. In unadjusted models using both accelerometer-measured PA and measured obesity (model

TABLE 5 Comparison of estimated association between meeting moderate-to-vigorous physical activity guidelines and obesity using both measured and self-reported anthropometry and physical activity, unadjusted and adjusted

	Unadjusted			Adjusted		
	PR	95% CI	% Difference	PR	95% CI	% Difference
Model 1	0.62***	(0.50, 0.78)	(reference)	0.77*	(0.62, 0.97)	(reference)
Model 2	0.62***	(0.53, 0.74)	0.0	0.79**	(0.66, 0.93)	2.6
Model 3	0.55***	(0.42, 0.71)	−11.3	0.71**	(0.55, 0.91)	−7.8
Model 4	0.56***	(0.47, 0.68)	−9.7	0.73**	(0.61, 0.88)	−5.2

Note: Model 1 classifies obesity using measured heights and weights and physical activity using accelerometry. Model 2 classifies obesity using measured heights and weights and physical activity using self-reports. Model 3 classifies obesity using self-reported heights and weights and physical activity using accelerometry. Model 4 classifies obesity using self-reported heights and weights and physical activity using self-reports. Adjusted models include control for county of residence, age, gender, race/ethnicity, educational attainment, property value tertiles, employment status, body mass index categories, fair or poor self-reported health, self-reported diagnosis of depression, stressed all or most of the time (past 30 days) and general happiness sometimes, a little or not at all.

Abbreviations: CI, confidence interval; PR, prevalence ratio.

*$P < 0.05$.

**$P < 0.01$.

***$P < 0.001$.

TABLE 6 Perceived physical activity and weight status predicting objectively measured weekly minutes of MVPA and weight (n = 728)

Perceived measure	Objective measure			
	Mean minutes per week of MVPA			
	Unadjusted		Adjusted	
	Estimate	(95% CI)	Estimate	(95% CI)
Perceived physical activity				
Does not consider self physically active	1.00	—	1.00	—
Considers self physically active	87.1***	(62.4, 111.8)	64.6***	(36.9, 92.3)
	Mean weight (kg)			
	Unadjusted		Adjusted	
	Estimate	(95% CI)	Estimate	(95% CI)
Perceived weight status				
About the right weight or underweight[a]	1.00	—	1.00	—
Somewhat overweight	13.9***	(11.7, 16.1)	15.3***	(13.3, 17.3)
Very overweight	35.0***	(31.7, 38.3)	36.5***	(33.2, 39.7)

Note: Adjusted models include control for county of residence, age, gender, race/ethnicity, educational attainment, property value tertiles, employment status, body mass index categories, fair or poor self-reported health, self-reported diagnosis of depression, stressed all or most of the time (past 30 days) and general happiness sometimes, a little or not at all.

Abbreviations: CI, confidence interval; MVPA, moderate-to-vigorous physical activity.

[a]Underweight includes somewhat underweight or very underweight.

***$P < 0.001$.

1), those participants who met MVPA guidelines had 38% lower prevalence of obesity compared with who did not meet MVPA guidelines. The unadjusted, estimated relation between PA and obesity using self-reported MVPA and measured obesity (model 2) was nearly identical (PR = 0.62, 95% CI = 0.53, 0.74). However, models using accelerometer-derived MVPA and self-reported obesity (model 3) (PR = 0.55, 95% CI = 0.42, 0.71) or both self-reported MVPA and obesity (model 4) (PR = 0.56, 95% CI = 0.56, 0.68) overestimated the observed association relative to model 1. Adjusted model estimates, however, were similar. Models 3 and 4 somewhat overestimated the observed association, albeit to a lesser extent.

Table 6 shows the relation between perceived PA and measured as well as perceived weight status measured weight. Both unadjusted and adjusted models demonstrated that perceived PA and weight were strongly associated with measured metrics. In adjusted models, participants who perceived themselves as physically active performed 64.6 min week^{-1} of MVPA (95% CI = 36.6, 92.9) more than those participants who did not consider themselves physically active. Participants who perceived themselves as somewhat overweight or very overweight weighed, on average 15.3 (95% CI = 13.3, 17.3) and 36.5 kg (95% CI = 33.2, 39.7) more than those who perceived their weight as underweight or about the right weight.

4 | DISCUSSION

Although nearly twofold more participants self-reported meeting CDC guidelines for MVPA compared with accelerometry, there was little evidence of differential misreporting. The patterns of reported and measured participation in MVPA were largely consistent across all sociodemographic factors, health and mental well-being. Education and gender were the only factors associated with differential PA underreporting. No characteristics were differentially related to PA overreporting. Contrary to prior studies that found that men tend to overreport their PA, these results showed that males had a higher prevalence of PA underreporting, compared with females; however, our sample was predominately female (81.3%).[11,17] In line with prior studies, these results demonstrated that higher education was associated with lower PA underreporting.[11,17] Results also showed that participants who perceived themselves as active performed over 60 min week^{-1} of MVPA more than participants who did not. This suggests that although adults may have difficulty recalling the exact type and absolute duration of PA performed, they are aware of the relative amount of PA performed.

For weight, underreporting was most common.[8–17] However, across all categories, the self-reported mean weight was within 1–2 kg of measured weight. As with prior studies, there was evidence of differential misreporting by gender and BMI category as well as greater accuracy in reporting among participants with higher education.[21,23,25,26,29] There was also evidence that married participants more accurately reported their weight. Perceived weight status was highly associated with measured weight.

There was some indication of differential reporting of weight by mental well-being. Self-reported fair or poor health, frequent stress and infrequent happiness, but not depression, were associated with a higher prevalence of weight overreporting. This finding adds to the mixed body of evidence evaluating misreporting of weight by mental well-being and warrants further study given that these factors have

been identified as strong predictors of weight change.[27,28] Importantly, perceived weight status, arguably a composite measure encompassing subjective assessment of weight and psychosocial factors (e.g., perceptions and attitudes), was associated with measured weight even after adjustment.

The results of this study support the use of self-reported weight data in diverse populations. In addition, self-reported PA and perceived PA follow similar reporting patterns as objective PA and are predictive of objective PA. This suggests that self-reported PA may be adequate in ranking individuals or may be used as a proxy measure for actual PA. The collection of in-person anthropometric data, by trained research staff, and PA data via accelerometry is resource intensive for researchers and can place undue burden on participants.[3,36] Moreover, in-person data collection risks interruption in the event of large-scale disasters. The accuracy afforded by objectively measured PA and anthropometrics often comes at the cost of not having a large sample size due to the feasibility of scaling up such resource intensive data collection. Larger sample sizes, however, afford researchers greater power to detect minute associations they might otherwise not be able to observe, such as factors predicting longitudinal weight change.[37] In addition, some researchers have moved their self-reporting data collection tools online, utilizing social media platforms for recruitment and to maintain study engagement, or to mobile devices.[6,7,24,38,39] Such tools allow for the assessment of changes in both PA and weight can occur in real time at lower cost and with less participant burden.[6,7,24,38,39] One way to control for specific biases in a given population of interest is to pair self-reported tools with a small, randomized subsample of measured PA and anthropometrics to allow researchers to calibrate their self-reported assessment tools and control for the specific biases in their populations of interest.[2,11] Another method, should differential misreporting not be present, would be using a continuous measure of self-reported PA combined with ranking, such as quartiles or quintiles of minutes per week of MVPA, which would be internally valid categorization scheme with the potential trade-off of reduced generalizability.

This study was not without its limitations. First, by design, this study oversampled women, households with lower residential property values and Hispanics, which may limit the generalizability of these findings. Second, participants had prior knowledge that both self-reported and measured anthropometrics would be collected. Third, a large portion of sample was excluded from the analysis due to missing self-reported anthropometric or health data. The excluded participants were younger, more diverse, less educated and more likely to be unemployed or not in the labour force. It is possible that the observed biases between self-reported and measured PA and weight could have been larger if these participants had complete data. However, these results highlight the need for additional work to develop self-reported data collection tools tailored to specific diverse communities. Moreover, the high prevalence of participants missing anthropometric data may support the notion that, overall, prior knowledge of the collection of self-reported and measured anthropometrics did not lead participants to prepare or pre-plan their self-reported responses. Fourth, our sample size for this analysis was limited. Although we believe have sufficient sample size across most population subgroups, the prevalence of underreporting of MVPA and overreporting of weight rare and positivity may have been violated; therefore, estimates are not causal and should be interpreted with caution. Fifth, it should be noted that both the sociodemographic characteristics as well as measures of health and mental well-being evaluated in this study were themselves self-reported, with the exception of measured BMI categories, and may therefore be subject to bias. Sixth, 3 days of accelerometry data were used to characterize objective MVPA, where some studies have suggested that 6 days to 1 week may be necessary to establish habitual activity at all levels of PA.[40] Seventh, self-reported PA was only a binomial indicator asking whether participants performed at least 2.5 h of MVPA weekly and therefore did not all for the examination of the magnitude of misreporting in minutes. However, the models of perceived PA and measured mean minutes per week of MVPA suggest that these differences are large.

This study also had a number of key strengths. First, misreporting of PA and weight as well as the relation between perceived and measured PA and weight were able to be simultaneously evaluated. Second, a rigorous modified Poisson regression approach was used to examine factors predictive of underreporting or overreporting, which is more robust than standard logistic regression models. Third, an array of sociodemographic, health and mental well-being factors were able to be jointly examined, some of which have not been previously examined as predictive of PA or weight misreporting. Fourth, this study went through great lengths to obtain a unique population of predominantly female, rural Hispanics in Yakima County, a population that is underrepresented in similar studies. This population combined with participants recruited from King and Pierce counties generated a sample that was diverse in terms of both demographics and socioeconomic status.

5 | CONCLUSION

Self-reported PA and weight showed some systematic biases by sociodemographic factors as well as across measures of health and mental well-being. However, self-reports were highly predictive of their objective counterparts. Self-reported and perceived measures of PA and weight remain valuable and may be adequate should the collection of objective metrics be infeasible either due to cost or logistics. However, adjustment for systematic differences should be considered and tailored to the specific population under study. Future studies should examine the magnitude of, and characteristics associated with, misreporting of change in PA and anthropometrics over time.

CONFLICT OF INTEREST STATEMENT

Adam Drewnowski has received grants, honoraria and consulting fees from numerous food, beverage and ingredient companies and from other commercial and non-profit entities with an interest in diet quality and nutrient density of foods. The University of Washington

receives research funding from public and private sectors. All other authors have no conflicts of interest to declare.

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APPENDIX A

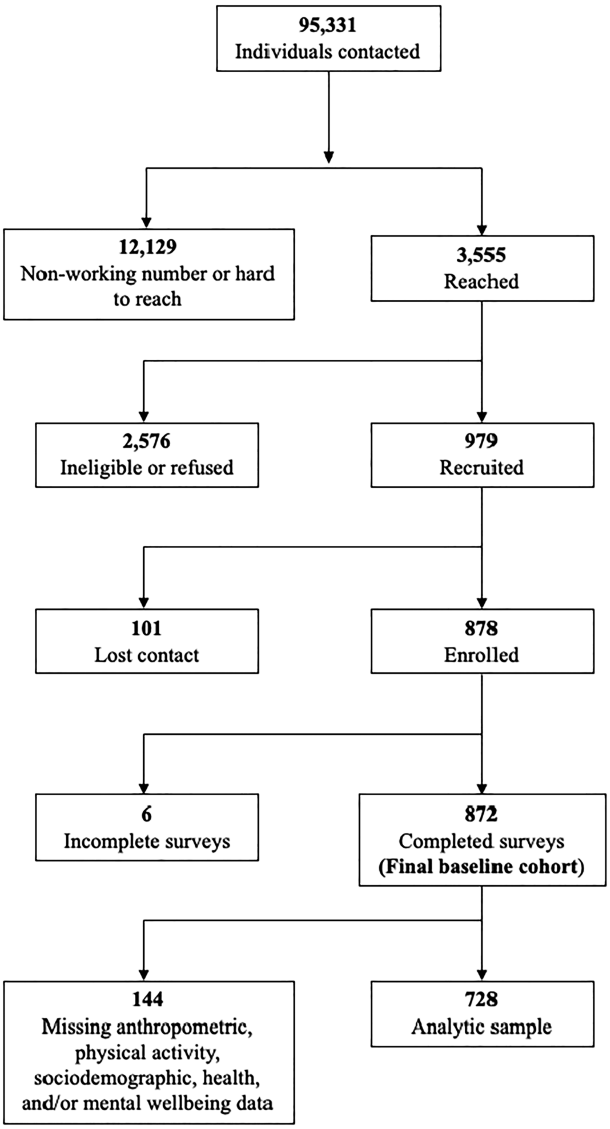

FIGURE A1 Seattle Obesity Study III participant enrolment/retention and analytic sample flow diagram at baseline

TABLE A1 Select sociodemographics by county and analytic sample inclusion, full Seattle Obesity Study III sample (n = 872)

	Overall	King	Pierce	Yakima	Sample	Nonsample
	n = 872	n = 356	n = 167	n = 349	n = 728	n = 144
Characteristics	%	%	%	%	%	%
Age						
21–39 years	33.4	21.6	40.7	41.8	32.0	30.3
40–49 years	29.8	25.3	25.8	36.4	29.0	34.0
≥50 years	36.8	53.1	33.5	21.8	39.0**	25.7**
Gender						
Female	82.0	67.7	89.2	93.1	81.3	85.4
Male	18.0	32.3	10.8	6.9	18.7	14.6
Race/ethnicity						
White	46.7	75.8	74.9	3.4	52.5***	17.0***
Hispanic	41.9	5.9	6.6	95.4	34.9***	77.1***
Other (Black, Asian, etc.)	11.1	18.0	18.0	0.9	12.6**	3.5**
Marital status						
Unmarried/single/divorced	42.1	53.1	31.1	36.1	42.9	38.2
Married	57.7	46.9	68.3	63.6	57.1	60.4
Education						
High school or less	35.6	5.9	7.2	79.4	28.7***	70.1***
Some college	21.6	23.6	31.1	14.9	23.1*	13.9*
College graduate/grad school	42.9	70.5	61.7	5.7	48.2***	16.0***
Employment						
Employed	70.2	80.9	84.4	52.4	74.7***	47.2***
Unemployed or not in labour force	29.7	18.8	15.6	47.6	25.3***	52.1***

Note: Percentages reflect column totals. County representation for participants included in the analytic sample was 46.1% King county, 22.7% Pierce county and 31.3% Yakima county. County representation for participants not included in the analytic sample was 21.2% King county, 6.0% Pierce county and 72.8% Yakima county. Race/ethnicity was missing from three participants, marital status was missing from three participants and employment status was missing from one participant; therefore, column totals for these attributes will not sum 100%. P value reflects a test of proportions for each characteristic comparing sample and nonsample participants. n = sample size.

*$P < 0.05$.

**$P < 0.001$.

***$P < 0.0001$.

TABLE A2 Accuracy in moderate-to-vigorous physical activity reporting by self-reported meeting of physical activity guidelines

	Self-reported MVPA			
	Met guidelines (*n* = 423)		Did not meet guidelines (*n* = 305)	
	% Accurate	% Overreport	% Accurate	% Underreport
Overall	42.1	57.9	85.9	14.1
Age				
21–39 years	12.5	17.3	30.2	4.9
40–49 years	11.8	15.4	27.5	3.9
≥50 years	17.7	25.3	28.2	5.2
Gender				
Female	30.5	48.9	74.8	9.2
Male	11.6	9.0	11.1	4.9
Race/ethnicity				
White	29.8	32.2	33.4	5.9
Hispanic	7.1	18.0	42.3	6.2
Other (Black, Asian, etc.)	5.2	7.8	10.2	2.0
Marital status				
Unmarried/single/divorced	18.2	22.5	38.7	7.2
Married	23.9	35.5	47.2	6.9
Education				
High school or less	5.9	15.6	32.5	6.2
Some college	8.7	13.7	22.0	2.0
College graduate/grad school	27.4	28.6	31.5	5.9
Employment				
Employed	32.6	45.4	60.0	10.2
Unemployed or not in labour force	9.5	12.5	25.9	3.9
Measured body mass index categories				
Underweight or normal weight	17.3	17.7	15.7	3.0
Overweight	14.7	17.0	23.9	3.9
Obese	10.2	23.2	46.2	7.2
Self-reported health				
Good, very good or excellent	37.6	46.8	57.4	10.8
Fair or poor	4.5	11.1	28.5	3.3
Depression				
No	32.2	45.9	63.6	10.5
Yes	9.9	12.1	22.3	3.6
Stressed (past 30 days)				
Some, a little of the time or not at all	37.8	48.9	61.6	12.1
All or most of the time	4.3	9.0	24.3	2.0
General happiness				
All or most of the time	32.4	45.4	59.0	10.8
Some, a little of the time or not at all	9.7	12.5	26.9	3.3

Note: Accurate PA reporting was defined as agreement between self-reported and accelerometer MVPA such that both metrics classified the individual as meeting the PA guidelines or classified the individual or not. PA underreporting was defined as self-reporting that one did not meet PA guidelines but had accelerometer values that indicated that they performed ≥2.5 h of MVPA per week. PA overreporting was as defined as self-reporting that one did meet the PA guidelines but had accelerometer values that indicated <2.5 h of MVPA per week.

Abbreviations: MVPA, moderate-to-vigorous physical activity; PA, physical activity.