Research Article

Obesity and anthropometry in spina bifida: What is the best measure

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Objective: Diagnosis of obesity using traditional body mass index (BMI) using length may not be a reliable indicator of body composition in spina bifida (SB). We examine traditional and surrogate measures of adiposity in adults with SB, correlated with activity, metabolic disease, attitudes towards exercise and quality of life.

Design: Adult subjects with SB underwent obesity classification using BMI by length and arm span, abdominal girth and percent trunk fat (TF) on dual energy X-ray absorptiometry (DXA). Quality of life measures, activity level and metabolic laboratory values were also reviewed.

Results: Among eighteen subjects (6 male, 12 female), median age was 26.5 (range 19–37) years, with level of lesion 16.7% ≤L2, 61.1% L3-4, and 22.2% ≥L5, respectively. Median weight was 71.8 (IQR 62.4, 85.8) kg, similar between sexes (P = 0.66). With median length of 152.0 (IQR 141.8, 163.3) cm, median conventional BMI was 29.4 m/kg^2, with 7 (43.8%) subjects with BMI >30. Median BMI by arm span was 30.2 m/kg^2, abdominal girth of 105.5 cm, and TF 45.7%. More subjects were classified as obese using alternate measures, with 9 (56.3%) by arm span, 14 (82.4%) by abdominal girth and 15 (83.3%) by TF (P = 0.008). Reclassification of obesity from conventional BMI was significant when using TF (P = 0.03). No difference in quality of life measures, activity level and metabolic abnormalities was demonstrated between obese and non-obese subjects.

Conclusions: Conventional determination of obesity using BMI by length is an insensitive marker in adults with SB. Adults with SB are more often classified as obese using TF by DXA.

Keywords: Anthropometric measures, Body fat, Body mass index, Obesity, Spina bifida

Introduction

In the United States, there has been a dramatic increase in the prevalence of obesity over the past two decades, with the Center for Disease Control (CDC) reporting obesity in 2012 in 35% of adults and 17% of adolescents and children, and higher prevalence in people with physical impairments and immobility.[1–3] Obesity, and specifically central adiposity,[4–6] has been linked to the development of metabolic syndrome, an amalgam of symptoms predictive of morbidity and mortality due to cardiovascular disease, stroke, and diabetes mellitus.[7–11] Furthermore, implications of obesity may also correlate with activity level, attitudes toward exercise and quality of life.

In the past 40 years, advances in understanding and care of spina bifida (SB) has resulted in significant improvements in life expectancy, with 78% reaching adulthood.[12] With increasing life expectancy, risk of chronic medical problems such as cardiovascular disease, renal impairment, obesity and diabetes will become an important part of medical care for the growing adult SB population. People with SB are more commonly obese, with 35–37% prevalence reported in the literature, although some advocate that true prevalence of obesity may be even higher.[13,14] Risk factors for obesity in this population include limited ambulation, sedentary lifestyle, decreased lean body mass and resting energy expenditure, and

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neuroendocrine abnormalities due to hydrocephalus.[14] The importance of recognizing and addressing obesity in people with SB is clear, but the development of more accurate methods of obesity measurement remains a continual challenge. Conventional methods of classifying obesity using body mass index (BMI) based on height and weight in the SB population are limited by lower limb and trunk hypoplasia, vertebral anomalies, musculoskeletal deformities, and body fat redistribution may even further limit accuracy.[15] Furthermore, conventional calculations of BMI does not specify body fat distribution despite the evidence that central obesity has the highest association with increased mortality.[16,17]

Conventional BMI calculations are known to underestimate obesity in patients with spinal cord injury (SCI), due to lower muscle mass in the lower extremities and torso and concomitant higher fat mass.[18] Similarly, these changes are shared with adults with SB, reflecting a common pitfall of using traditional measures of BMI in these populations. DXA has been identified as one of the most accurate methods of measuring body composition in people with SCI.[19–21] Studies of physical activity and body composition in people with SB have therefore employed differing methods of defining obesity, ranging from calculation of BMI using height measured from joint to joint,[22–24] BMI using arm span,[14] or dual energy X-ray absorptiometry (DXA) trunk fat percentage.[18,25–26] To address the lack of consensus regarding obesity measurement standards in adults with SB, the primary goal of our study is to assess the accuracy of various anthropometric measures of determining adiposity and assess the sensitivity of each measure in characterizing obesity. As a secondary goal, we also investigate the correlation between obesity and activity level, attitudes toward exercise, and subsequent effects on quality of life and risk factors for metabolic syndrome.

Methods

We performed an institutional review board approved cohort comparison of adult (≥18 years old) subjects with SB. Eighteen consecutive subjects were identified and enrolled in the clinic setting and asked to complete a standardized questionnaire at our institution (Rehabilitation Institute of Chicago, Chicago, IL, USA). Subject demographics including age at the time of study, sex, level of neurologic lesion, ambulatory status, history of ventriculo-peritoneal shunt and mobility were obtained from subject report and chart review of the electronic medical record. The questionnaire consisted of the Satisfaction with Life Scale (SWLS),[27] the Functional Mobility Scale (FMS),[28] an adaptation of the Barriers to Physical Activity and Disability Survey (B-PADS),[29] the SF-12 Health Survey, with modification for those with spinal cord injury (SF-12v2)[30] and a survey of approximate number of hours per week spent on specific activities (work, school sports and fitness, church, television or computer, social activities, and housekeeping). Overall quality of life was evaluated using the SF-12v2 questionnaire, consisting of Mental Health (MCS) and Physical Health Composite Scores (PCS).[30] The average value was calculated for mental and physical domains on a scale of 0 to 100, with a lower score indicating a lower quality of life. These MCS and PCS values were compared to age-matched average scores in the United States.[30] General satisfaction with life was evaluated using the SWLS, on a scale of 0 to 35, with a higher score indicating higher satisfaction.[27] Ambulatory status and mobility were evaluated on subject interview as well as using the FMS, with higher score indicating greater independence in mobility and ambulation.[28] The B-PADS was used to identify potential barriers to physical activity and exercise in subjects.[29]

Segmental height measurements (*segment 1* (sitting height) is measured from head to hip; *segment 2* is measured from spine to knee; *segment 3* is measured from knee to sole) were taken to the nearest centimeter using a stadiometer. Total length was calculated by summation of the three segmental measurements. Weight of the subject was obtained to the nearest kilogram with a wheelchair balance scale. Arm span was measured from the tip of the right middle finger to the tip of the left middle finger, with arms fully extended in 90-degree abduction with a flexible tape to the nearest centimeter. Conventional BMI (BMI by height) was calculated from measured weight and total length. BMI calculations using arm span (kg/m^2) were calculated as an alternative BMI determination using a measure of length that is typically unchanged between adults with SB and the general population. Abdominal circumference (cm) was measured at the level just above the uppermost lateral border of the ilium with no intervening clothing or gown, using a flexible tape to the nearest centimeter. Body composition measurement of percent trunk fat (TF) was obtained by DXA using Hologic QDR 4500A fan beam densitometer, using version 12.7.2 software (Hologic, Bedford, MA, USA). In this study, obesity was defined as percent TF by DXA of ≥30% in males and ≥35% in females, correlating to the 85th percentile[31] a BMI value $>30\ kg/m^2$, or an abdominal circumference >102 cm in males and >88 cm in females.[32] Overweight was defined as BMI value

>25 kg/m^2, or an abdominal circumference >94 cm in males or >80 cm in female.[32] These reference values for adiposity and obesity are based on population-based studies of the general adult community.

The electronic medical record was used to review available laboratory results, vital signs and medication history, including lipid panel, fasting blood sugar, hemoglobin A1c (HbA1c), blood pressure measurements and medications pertaining to diabetes, hypertension or hyperlipidemia. Any medications to treat hyperlipidemia, diabetes, or hypertension were also recorded. Laboratory and blood pressure values were defined as abnormal based on the following criterion: 1) triglyceride ≥ 150 mg/dL; 2) total cholesterol ≥ 200 mg/dL; 3) high-density lipoprotein (HDL) ≤ 40 mg/dL; 4) low-density lipoprotein (LDL) > 190 mg/dL; 5) fasting blood sugar ≥ 126 mg/dL; 6) HbA1c ≥ 6.5%; 7) systolic or diastolic blood pressure ≥ 130/85.[33] In cases in which multiple lab values or vital signs were available, all results were reviewed rather than averaging of measurements.

For statistical analysis, χ^2 tests were used for categorical variables. Mann-Whitney *U* test was used for scale variables. Scores for each questionnaire are reported in all patients as well as by sex and obesity, as judged by DXA percent TF. The four measures of obesity (BMI by length, BMI by arm span, abdominal circumference, and DXA percent TF) were also compared. For all statistical analyses, $P < 0.05$ was considered statistically significant. Analysis was performed using SPSS®, version 22 (IBM Corp., Armonk, NY, USA).

Results

Of the 18 subjects included in the study, six (33.3%) were male and 12 (66.7%) were female. Mean age at the time of the study was 26.5 years (range 19–37). Level of lesion was most commonly L3–L4 (61.1%) and most subjects had a history of ventriculo-peritoneal shunt (94.4%). No statistically significant differences existed between the male and female subjects included in the study in these demographics (Table 1).

Anthropometric measures of obesity

Results of anthropometric measurements are shown in Table 2. Median weight of patients was 71.8 kg (IQR 62.4, 85.8). Arm span was overall similar to total length (153.8 cm and 155.0 cm, respectively), but arm span measurements were significantly longer in males than in females (171.0 cm versus 148.0 cm, P = 0.005), while total length was similar between sexes. Median BMI calculated using total length was 29.4 kg/m^2 (IQR 26.1, 36.7). Median BMI calculated using arm span was 30.2 kg/m^2 (IQR 22.8, 34.9). While BMI by arm span tended to be lower in males (22.8 kg/m^2) than in females (34.9 kg/m^2) due to the significant difference in arm span between sexes, the difference in BMI between sexes was not statistically significant (P = 0.15) despite being clinically significant in terms of classification of obesity. Median abdominal girth was 105.5 cm (IQR 93.0, 111.0), without significant difference between sexes. In contrast, median DXA trunk fat % was 45.7% (IQR 36.5, 50.0), with significantly higher fat % in females than males (47.5% versus 31.0% respectively, P = 0.001).

By conventional BMI (calculated using height) cutoffs for obesity, seven (43.8%) subjects were obese, which was subsequently used as a baseline to compare alternate measures of obesity (Table 3). However, when BMI was calculated using arm span, two additional subjects were reclassified as obese for a total of nine (56.3%) patients. The difference in obesity classification between BMI using height versus arm span was not significantly different (P = 0.63). As shown in Figure 1 and Table 3, a significant increase in obesity classification using abdominal circumference and DXA trunk fat % (P = 0.06 and P = 0.03, respectively). By measure of abdominal girth, 14 (82.4%) subjects were obese, while 15 (83.3%) were obese by DXA trunk fat %. Missing data points for anthropometric

Table 1 Characteristics of patients. Statistical significance was calculated using Mann-Whitney *U* test.

	All (n = 18)	Male (n = 6)	Female (n = 12)	P-value
		median (range)		
Age	26.5 (19–37)	26.5 (21–29)	27.0 (19–37)	
Level of lesion		*n (%)*		0.89
Thoracic – L2	3 (16.7)	2 (33.3)	1 (8.3)	
L3–4	11 (61.1)	2 (33.3)	9 (75.0)	
L5 or lower	4 (22.2)	2 (33.3)	2 (16.7)	
VP shunt	17 (94.4)	5 (83.3)	12 (100)	0.62

VP, ventriculo-peritoneal.

Table 2 Anthropometric measures. Total length was calculated as the sum of segments 1 through 3 (as described in the methods of the manuscript). Statistical significance was calculated using Mann-Whitney *U* test.

	All (n = 18)	Male (n = 6)	Female (n = 12)	P (95% CI)
		median (IQR)		
Weight (kg)	71.8 (62.4, 85.8)	68.7 (58.6, 83.0)	71.8 (63.7, 86.8)	0.66
Arm span (cm)	153.8 (147.8, 163.3)	171.0 (162.0, 178.0)	148.0 (147.0, 153.75)	0.005
Total length - right (cm)	155.0 (137.8, 165.5)	159.0 (146.0, 169.0)	153.0 (137.5, 165.0)	0.58
Segment 1 - trunk (cm)	69.0 (67.0, 77.3)	69.0 (69.0, 70.0)	69.0 (66.0, 77.5)	
Segment 2R - spine to knee (cm)	43.0 (38.5, 48.6)	44.0 (40.0, 48.5)	42.0 (37.0, 48.5)	
Segment 3R - knee to heel (cm)	39.0 (35.0, 42.5)	45.0 (37.0, 48.0)	38.0 (34.5, 40.8)	
BMI (kg/m2)				
by total length (right)	29.4 (26.1, 36.7)	26.5 (25.3, 34.3)	29.4 (26.5, 38.1)	0.58
by arm span	30.2 (22.8, 37.4)	22.8 (21.5, 29.6)	34.9 (29.7, 27.5)	0.15
Abdominal girth (cm)	105.5 (93.0, 111.0)	98.0 (81.8, 109.8)	106.0 (101.5, 110.5)	0.46
DXA fat %	45.7 (36.5, 50.0)	31.0 (27.9, 37.3)	47.5 (45.6, 51.6)	0.001

BMI, body mass index (kg/m^2); DXA, dual X-ray absorptiometry.

data, as indicated in Table 3, were due to either encounter time limitations or subject preference.

Relationships between obesity on activity level and quality of life

Subjects were categorized as normal BMI versus obese using DXA trunk fat % standards and questionnaire elements were compared between the two groups (Table 4). No statistically significant difference in questionnaire elements between the two groups was demonstrated. Of note, in both the normal BMI and obese subject groups, SWLS scores were very similar, with average scores indicating an "average" satisfaction with life. Using the B-PADS questionnaire, the results suggest that most subjects (86.7% of obese patients and 100% of healthy subjects) want to join an exercise program, but a smaller portion (80% of obese subjects and 66.7% of healthy subjects) have ever exercised, with a smaller contingent ever having exercised regularly. Four (22.2%) subjects expressed concerns about exercising at a regular gym and five (27.8%) did not feel that a gym coordinator would know how to set up an exercise program to meet his or her needs. While all subjects report being instructed by a physician to exercise, only half recall being given specifics on where or how to do so. A minority of subjects identified family responsibilities or job as an obstacle for exercise, and most subjects identified parents, siblings, peers and role models as valuing exercise. Quality of life mental and physical health domains, as measured using the SF-12v2, tended to be lower in the obese subject group (46.5 ± 14.3 and 42.4 ± 10.3, respectively) compared to the normal BMI group (50.2 ± 14.6 and 50.3 ± 5.0, respectively), although this difference was not statistically significant (P = 0.74 and P = 0.2).

Correlations between obesity and risk factors for metabolic syndrome

Laboratory values were available for 13 (72.2%) subjects and are outlined in Table 4. In general, the obese group tended to have more adverse findings than the normal BMI group with respect to triglyceride, total cholesterol, HDL and LDL levels, while the healthy group had more adverse features in fasting blood glucose, HbA1c and blood pressure measurements, with one subject with normal BMI on two antihypertensive medications.

Table 3 Obesity classification using different anthropometric measures. Obesity was defined as BMI (by height or arm span) > 30 kg/m^2, abdominal girth > 102 cm in males or > 88 cm in females, or by DXA trunk fat % ≥ 30% in males or ≥ 35% in females. Overweight was defined as BMI > 25 kg/m2 or abdominal girth > 94 cm in males or > 80 cm in females. No accepted overweight standard value for DXA trunk fat percent is available. Statistical significance relative to conventional BMI (by height) was calculated using McNemar test.

	Normal	Overweight	Obese	Reclassified as Obese (compared to BMI by height)	P-value
			x (%)		
BMI by height (n = 16)	3 (18.8)	6 (37.5)	7 (43.8)	n/a	n/a
BMI by arm span (n = 16)	5 (31.3)	2 (12.5)	9 (56.3)	2 (12.5)	0.63
Abdominal girth (n = 17)	3 (17.6)	0 (0)	14 (82.4)	5 (29.4)	0.06
DXA trunk fat % (n = 18)	3 (16.7)	n/a	15 (83.3)	6 (33.3)	0.03

BMI, body mass index (kg/m^2); DXA, dual X-ray absorptiometry.

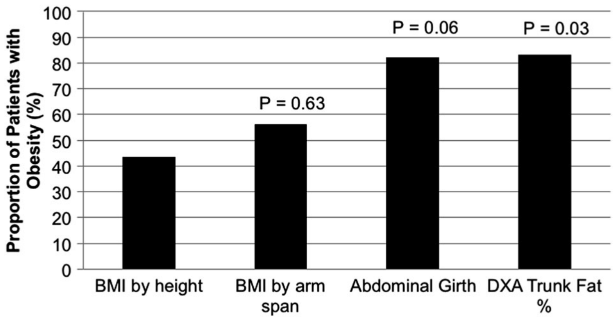

Figure 1 Reclassification of obesity using different anthropometric measures. Obesity was defined using BMI (by height or arm span), abdominal girth and DXA trunk fat percent as described in the manuscript. Classification by abdominal girth and trunk fat percentage resulted in a significantly increased rate of obesity. Statistical significance relative to conventional BMI (by height) was calculated using McNemar test. BMI, body mass index (kg/m2). DXA, dual X-ray absorptiometry.

Although trend towards adverse lab values was demonstrated in both groups for specific metabolic lab measurements, most subjects remained within the range of normal reference values. Of note, within the normal weight cohort, one subject had significantly abnormal lab values (fasting blood glucose 147 mg/dL, HbA1c 7.8%), which may have skewed the group average.

Discussion

Population-based studies have reported a 59% higher rate of obesity and 88% higher rate of physical inactivity in SCI compared to the general population,[34] but there is currently no accepted standard to identify obesity in individuals with SB. Although BMI (calculated using patient height) is used in the general population to identify individuals at elevated risk for obesity-related illness, it may not be a reliable indicator of body composition in adults with physical disabilities, with some suggesting lowering standard cutoffs for overweight and obese BMI in this population.[35] While alternative measures of obesity have been suggested in the SB population, the accepted standard method of measurement remains controversial.

Conventional BMI calculations using height may be confounded in the SB population due to inability to use standard stadiometer or joint contractures.[36,37] Use of arm span in the calculation of BMI in adults with SB has been reported,[13] but others have suggested inaccuracies due to decreased torso length.[36] Traditional anthropometric indices may be further limited in utility in adults with SCI or SB as these individuals tend to have lower lean tissue mass and higher fat mass,[38] suggesting that measures that focus on body composition, such as bioelectrical impedance analysis (BIA), abdominal circumference or DXA, may be more accurate.[39,40]

In this study, we compared conventional measurements of BMI using height to alternate methods of anthropometric measurement in adults with SB, a previously infrequently studied population of growing proportions and importance. By conventional BMI using height, 43.8% of subjects were obese. However, when using alternative measures, increase in obesity rate in the same population was demonstrated. When BMI was calculated using arm span, 12.5% of subjects were reclassified to obese. A significant increase in subjects classified as obese was seen when subjects were assessed using anthropometric measures that focused on body composition and fat distribution. Abdominal girth recategorized 29.4% of subjects initially deemed of normal BMI by conventional measures by height to obese, for a total of 82.4% obese. Trunk fat percentage by DXA similarly categorized 83.3% of subjects as obese. In other words, by using measurements that have been shown to better assess true body composition in the SCI population, obesity was identified almost two-fold as frequently, suggesting that a large portion of subjects thought to be of normal BMI by conventional measures may actually be obese.

In the general population, obesity and increased risk for metabolic syndrome have been associated with morbidity and mortality related to cardiovascular disease and diabetes.[7–11] SCI literature has suggested waist circumference is more strongly correlated with hyperlipidemia than BMI, and may be a more clinically relevant measure of adiposity.[37] Furthermore, waist circumference and hyperlipidemia have been shown in multiple studies in adults with SCI to be associated with a higher Framingham 30-year CVD risk score, earlier development of cardiovascular disease.[41–44] Similar research investigating cardiovascular disease in adults with SB is lacking, although one study identified risk factors for cardiovascular disease in 42% of young people with SB, with an association with physical activity[45] while another found a 32.4% prevalence of metabolic syndrome in adolescents with SB.[46] Identifying adults with SB at higher risk for metabolic syndrome, cardiovascular disease and diabetes would facilitate early prevention and intervention, and should be a priority to clinicians caring for a growing adult population.

Our results show no statistically significant difference in laboratory metabolic values between obese and normal BMI adults with SB, although the small cohort of people examined likely limits ability to

Table 4 Survey findings, metabolic data and obesity classification using trunk fat percentage. Obesity was defined by dual X-ray absorptiometry trunk fat % ≥ 30% in males or ≥ 35% in females. No significant differences in survey scoers between healthy and obese patients. Statistical significance was calculated using Mann-Whitney *U* test.

	Normal (n = 3)	Obese (n = 15)	P-value
	Mean (SD)		
Functional Mobility Scale (FMS)			0.53
Walking 5m	3 (0)	3 (1.6)	
Walking 50m	3 (0)	2.5 (1.9)	
Walking 500m	3 (0)	1.5 (1.4)	
Activity Level	7.5 (0.7)	5.6 (1.6)	0.23
Satisfaction with Life Scale (SWLS)	20 (9.9)	19.4 (7.8)	0.17
Barriers to Physcial Activity and Disability Surgery (B-PADS)	*n (%)*		
Q1 want to join an exercise program?	3 (100)	13 (86.7)	0.74
Q2 have you ever exercised?	2 (66.7)	12 (80)	0.74
Q2a If yes, did you ever have health probs that caused you to stop exercising?	0 (0)	2 (13.3)	0.77
Q3 Ever injured from exercising?	2 (66.7)	1 (6.7)	0.13
Q4 Gone to fitness center, but was a negative experience	0 (0)	2 (13.3)	0.74
Q5 ever exercised regularly?	2 (66.7)	8 (53.3)	0.74
Q6 Know of a fitness center you could get to?	3 (100)	11 (73.3)	0.5
Q6a If yes, want to go?	2 (66.7)	10 (66.7)	0.8
Q7 willing to spend money to go?	2 (66.7)	11 (73.3)	0.91
Q8 concerns about exercising at YMCA?	0 (0)	4 (26.7)	0.5
Q9 Do you feel coordinator at YMCA would know how to set up an exercise program to meet your needs?	1 (33.3)	12 (80)	0.25
Q10 feel an exercise program could help you?	3 (100)	15 (100)	1
Q12 Doctor ever told you to exercise?	2 (100)	10 (100)	1
Q12a If yes, specifics?	1 (50)	5 (50)	1
Q13 satisfied with physical appearance, so don't need to exercise	2 (100)	1 (10)	0.06
Q14 family responsibilities prevent exercise	0 (0)	3 (30)	0.61
Q15 Job prevents from exercise	0 (0)	1 (10)	1
Q16 parents/siblings value exercise	2 (100)	8 (80)	0.76
Q17 Peers value exercising	1 (50)	6 (60)	1
Q18 Role models value exercising	1 (50)	7 (70)	0.76
Weekly activities (hrs/wk)	*Mean (SD)*		
work	19.5 (21.9)	6.8 (10.0)	0.17
school	27.5 (10.6)	5.75 (13.3)	0.17
sports/fitness	4.5 (0.7)	1.7 (2.2)	0.17
church/religious	6 (8.5)	1.0 (1.5)	0.57
TV/computer	11 (5.7)	32.9 (29.2)	0.38
social activities/friends	9 (8.5)	1 (1.4)	0.23
housekeeping	3.4 (3.0)	9.0 (14.6)	0.17
SF-12 v2	*Mean (SD)*		
MCS	50.2 (14.6)	46.5 (14.3)	0.74
PCS	50.3 (5.0)	42.4 (10.3)	0.2
Metabolic Data	*Mean (SD)*		
Triglyceride (mg/dL)	116.5 (2.1)	127.2 (59.0)	
Total Cholesterol (mg/dL)	168 (18.4)	185.6 (21.1)	
HDL (mg/dL)	42 (0)	36.9 (10.8)	
LDL (mg/dL)	102.5 (17.7)	114.9 (16.7)	
Fasting Blood Glucose (mg/dL)	104 (37.6)	87.2 (14.9)	0.22
Hemoglobin A1c (%)	6.4 (1.9)	5.4 (0.3)	
Systolic Blood Pressure	130.3 (7.5)	125.8 (19.3)	0.7
Statin medication	none	none	
Diabetes medication	none	none	
Hypertensive medication	1 patient	none	

MCS, Mental Health Composite Score; PCS, Physical Health Composite Score; HDL, high density lioprotein; LDL, low density lipoprotein.

detect statistical significance. Of interest, despite 20% of adults with laboratory values suggesting hyperlipidemia, none were prescribed medication for hyper-lipidemia. Similarly, 56% of adults had documented blood pressures >130/85 mm Hg, but only one was prescribed antihypertensive medication.

Adults with SB, regardless of obesity, tended to report an average satisfaction with life (SWLS questionnaire) and mental and physical quality of life (SF-12v2 questionnaire) scores comparable to average scores in the United States. While no statistically significant difference in any questionnaire elements between the two groups was demonstrated, several findings are of importance regarding overall patterns and attitudes towards exercise. Using the B-PADS questionnaire, most adults with SB (88.9%) expressed a desire to join an exercise program, which was discordant with the proportion actually reporting a history of ever exercising in their lifetime (77.8%) and an even smaller portion exercising regularly (55.6%). One-fourth of adults surveyed expressed concerns about exercising at a regular gym due to their physical limitations, and did not feel that a gym coordinator would be able to help set up an exercise program for them. While 100% of adults with SB had been instructed by a physician in the past to exercise, unfortunately, only half report being given specifics as to how to do so, indicating as clinicians caring for this population, significant improvements in education may help facilitate exercise. While a minority of subjects identified family or work responsibilities as a restriction for exercise, it appears that the most common reasons cited as an obstacle for exercise are monetary concerns and lack of knowledge of appropriate gyms and exercises to meet their needs.

Despite the advantages of this study in a relatively infrequently studied population, there are several limitations that deserve mention. Firstly, the small number of adults with SB included limits the generalizability of results and ability to detect statistically significant differences. Secondly, while we demonstrate an important finding of high rate of reclassification of adults with SB as obese, metabolic and clinical correlation is limited by the snapshot of lab values and vital signs. Ideally, long-term follow-up to determine lifetime risk for diabetes, hypertension, hyperlipidemia and cardiovascular morbidity and mortality would be assessed relative to earlier anthropometric measurements of obesity. Finally, with any small cohort study of subjects, selection bias for inclusion and subject mix not representative of the overall adult SB population from a tertiary referral institution may be a confounder.

Conclusion

Currently no standard measure of adiposity and obesity in adults with SB exists, with current literature suggesting that conventional measures of BMI are flawed in this population. In comparing conventional measurements of BMI using height to alternate methods of anthropometric measurement in adults with SB, BMI measurements using height may underestimate true incidence of obesity in this population by almost half. In this study, abdominal circumference and DXA trunk fat percentage were most sensitive in determining obesity.

Activity level, quality of life and attitudes toward exercise were similar regardless of obesity. While exercise is accepted as important by both clinicians and adults with SB, actual execution of exercise may be limited by adequate instruction and accessibility to appropriate facilities. Earlier incorporation of community based physical activity may help change the frequency of exercise behavior in adults with disabilities as they age, and contribute to reduced risk of obesity and potentially of metabolic syndrome. Clinicians should discuss these issues early and often, and provide national and local resources for adaptive sports and recreation.

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