ADAPTED PHYSICAL ACTIVITY QUARTERLY, 2005, **22**, 356-370

Test Items and Standards Related to Body Composition on the Brockport Physical Fitness Test

Francis X. Short and Joseph P. Winnick
State University of New York, College at Brockport

This manuscript examines the validity and reliability of the tests used to measure body composition in the Brockport Physical Fitness Test. More specifically, information is provided on skinfold measures and body mass index and their applicability to youngsters with mental retardation and mild limitations in fitness, visual impairment (blindness), cerebral palsy, spinal cord injury, or congenital anomalies or amputations. The rationale for criterion-referenced standards for these test items for youngsters with these disabilities is provided along with some data on attainability of those standards. Possible ideas for future research are recommended.

Body composition is that component of health-related physical fitness that provides either an estimate of the degree of leanness or fatness of the body or an indication of the appropriateness of one's body weight for a given height. The relationships of these two aspects or subcomponents of body composition to test items and criterion-referenced standards in the Brockport Physical Fitness Test (BFPT; Winnick & Short, 1999) are depicted in Figure 1.

Tests of body composition in the BPFT include skinfolds (triceps, subscapular, and calf) and body mass index. Testers have some latitude in the selection of body composition test items, but the sum of two skinfolds generally is the recommended test item and body mass index (where appropriate) is usually the optional test item. For a description of test items or more specific information on test item selection, readers are referred to the test manual (Winnick & Short, 1999).

Information pertaining to the validity and reliability of the BPFT body composition test items is discussed under separate headings. The validity section attempts to establish relationships between skinfold measures or body mass index and health, provide the bases for the criterion-referenced standards, and present available attainability data for the groups associated with a disability covered by the BPFT. Following the reliability section is a brief discussion including recommendations for future research.

Francis X. Short is Dean, School of Arts and Performance, State University of New York, College at Brockport, Brockport, NY 14420. E-mail: fshort@brockport.edu. Joseph P. Winnick is Distinguished Service Professor with the Department of Physical Education and Sport, State University of New York, College at Brockport, Brockport, NY 14420. E-mail: jwinnick@brockport.edu.

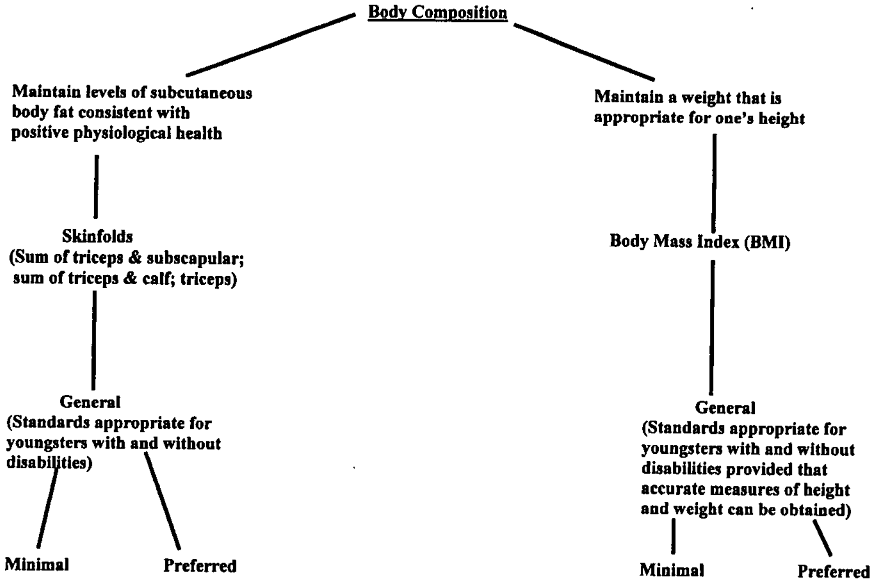

Figure 1—Relationships among subcomponents, test items, and standards for body composition. From *The Brockport Physical Fitness Test Manual*, p. 27, by J. Winnick and F. Short, 1999. Champaign, IL: Human Kinetics. Reprinted with permission.

Validity

Since about 1980, measures of body composition have been included in test batteries that purport to assess health-related aspects of physical fitness. For example, skinfolds and/or body mass index have been included in the following tests: Health Related Physical Fitness Test (American Alliance for Health, Physical Education, Recreation, & Dance, 1980), Project UNIQUE (Winnick & Short, 1985), Physical Best (McSwegin, Pemberton, Petray, & Going, 1989), and the FITNESSGRAM (Cooper Institute for Aerobics Research, 1992, 1999). The inclusion of measures of body composition in fitness tests for children and adolescents is justified on the grounds that the prevention of obesity can reduce the risk of heart disease (Cooper Institute for Aerobics Research, 1999) as well as by the observation that today's youngsters are fatter than those of previous generations (Cooper Institute for Aerobics Research, 1999; Hoelscher et al., 2004). Measures of body composition, therefore, are linked to body fat values in the establishment of criterion-referenced standards.

It is well-established that obesity represents a significant health problem for both children and adults alike (Cooper Institute for Aerobics Research, 1992; Rush, 2004). Obesity is typically defined in terms of the presence of a large amount of body fat expressed as a percentage of total body mass. High percent body fat values have been tied to higher mortality and morbidity rates in adults and with risk factors associated with heart disease in children. Lohman (1994) has summarized some of the literature that describes the relationship of body composition to health. This information will not be reiterated here, but as Rimmer (1994) has written, "there is little argument that obesity is linked to a number of diseases that increase the likelihood of early death" (p. 114).

The BPFT has adopted the percent body fat healthy fitness zone values recommended in the FITNESSGRAM (Cooper Institute for Aerobics Research, 1992, 1999) to represent the criterion standards for appropriate body composition. The FITNESSGRAM utilizes a 10-25% body fat range for boys and a 17-32% body fat range for girls. Individuals who are able to stay below the higher value (i.e., 25% for boys and 32% for girls) in the range as adults "will not be at greater risk for cardiovascular disease and diabetes" (Lohman, 1994, p. 64). Youngsters should also strive to stay above the lower value in the range. Individuals who are excessively lean may also experience health-related problems, especially if the leanness can be traced to poor nutrition (Cooper Institute for Aerobics Research, 1992).

In the FITNESSGRAM, the percent body fat ranges discussed above comprise what is called a "healthy fitness zone." Although youngsters, at the very least, should attempt to stay within the healthy fitness zone, Lohman (1994) recommends a more optimal range. The optimal range is 10-20% for boys and 17-25% for girls. The rationale for the optimal range is that children will tend to get fatter with increasing age. It was reasoned, therefore, that if a youngster can stay within the optimal range as a child, he or she will more likely be able to stay within the healthy fitness zone as an adolescent or adult even if some body fat is added (Lohman, 1994). The lower percent body fat boundaries are the same for the healthy fitness zone and the optimal range. In the FITNESSGRAM, CR standards are provided for the healthy fitness zone percentages only.

In the BPFT, the criterion-referenced standards for the skinfold measures and body mass index scores are related to both sets of percent body fat ranges. For boys, the 10-25% range constitutes a basis for "minimal" standards, while the 10-20% range is considered to be the basis for "preferred" standards. For girls, the basis for the minimal standards is represented by the 17-32% range of body fat, while the 17-25% range is the basis for the preferred standards. These values were developed from the work of Williams et al. (1992), where it was found that cardiovascular risk factors increased for boys above 25% fat and for girls above 32% fat using data from the Bogalusa Heart Study (Lohman, 1992).

Skinfolds

Three skinfold options exist in the BPFT: sum of the triceps and calf (TC) skinfolds, sum of the triceps and subscapular (TS) skinfolds, and triceps-only (TO) skinfold. The TC skinfold is the recommended test item in the FITNESSGRAM. It was selected because it has acceptable levels of validity and reliability (Lohman, 1994) and presumably because the calf site is often more easily accessible to a tester than the subscapular site. Evidence of concurrent validity for the TC skinfolds is provided, in part, by a correlation of .88 between the sum of the triceps and calf skinfolds and a multicomponent model (bone density, water content of the body, and mineral content of the body) used to determine percent body fat (Lohman, 1994).

In the BPFT the TC skinfolds is recommended for youngsters with MR, VI, and, depending upon the nature of the impairment (i.e., availability of triceps and calf sites), CA/A. For youngsters with CP, SCI, and some forms of CA/A, however, the recommended item is the TS skinfolds. Concurrent validity can also be claimed for the TS skinfolds in part because of a correlation of .89 with the multicomponent model of determining percent body fat (Lohman, 1994). Although the subscapular site generally is more difficult to access than the calf site, it is preferred for individuals with lower limb disabilities because the subscapular measure more likely will be taken over active muscle. Some experts feel that measures taken over paralyzed (or possibly impaired) musculature will yield considerably higher skinfold readings (Rimmer, 1994), thus overestimating percent body fat.

Although the subscapular skinfold is a more desirable site than the calf for people with lower limb disabilities, it may not be easily accessible. Wheelchair-backs or body braces may prevent reasonable access to the subscapular site. In cases such as these, testers have the option of measuring only the triceps fold. The TO skinfold also was used as an optional test of body composition in the Physical Best physical fitness test. The relationship between a single skinfold and percent body fat, however, generally is less than when multiple skinfold sites are used (McSwegin et al., 1989). Consequently, testers should use the TO skinfold to assess body composition only when no other options are available.

Standards Both minimal and preferred standards for the three sets of skinfold tests are given in Table 1a and 1b. The TC skinfold standards were derived from equations provided by Lohman (1994):

- % fat (males, aged 6-18) = .735 (TC skinfold) + 1.0
- % fat (females, aged 6-18) = .610 (TC skinfold) + 5.0

Depending upon level of maturation for subjects 8-18 years of age, coefficients of determination (R^2 values) ranged from .77 – .80 and standard errors of estimate varied from 3.4 – 3.9% body fat when the TC skinfold equations were used to predict body fat from a multicomponent model (Slaughter et al., 1988). TS skinfold standards also come primarily from the work of Slaughter et al. (1988). The equations from which the CR standards were derived are as follows:

- % fat (females, aged 6-18) = 1.33 (TS skinfold) – .013 (TS skinfold)2 + 2.5 (when TS skinfold is 35 mm or less)
- % fat (females, aged 6-18) = .546 (TS skinfold) + 9.7 (when TS skinfold is greater than 35 mm)
- % fat (males) = 1.21 (TS skinfold) – .008 $(\text{TS skinfold})^2$ – I where

  I = 2.6 (10-year olds)

  I = 3.1 (11-year olds)

  I = 3.6 (12-year olds)

  I = 4.3 (13-year olds)

  I = 4.9 (14-year olds)

  I = 5.5 (15-year olds)

  I = 6.1 (16-year olds)

  I = 6.1 (17-year olds)

Table 1a Minimal General Standards for Measures of Body Composition

	Males									
	Percent Fat M		Triceps plus Subscap. Skinfold (mm.) M		Triceps plus Calf Skinfold (mm.) M		Triceps Skinfold (mm.) M		Body Mass Index M	
Age	U	L	U	L	U	L	U	L	U	L
10	10	25	11	28	12	33	7	19	15.3	21.0
11	10	25	12	29	12	33	7	19	15.8	21.0
12	10	25	13	30	12	33	7	19	16.0	22.0
13	10	25	13	30	12	33	7	18	16.6	23.0
14	10	25	14	31	12	33	7	18	17.5	24.5
15	10	25	14	32	12	33	7	17	18.1	25.0
16	10	25	15	33	12	33	7	17	18.5	26.5
17	10	25	15	33	12	33	7	16	18.8	27.0
	Females									
10	17	32	18	41	20	44	10	24	16.6	23.5
11	17	32	18	41	20	44	10	24	16.9	24.0
12	17	32	18	41	20	44	10	24	16.9	24.5
13	17	32	18	41	20	44	10	23	17.5	24.5
14	17	32	18	41	20	44	10	23	17.5	25.0
15	17	32	18	41	20	44	10	23	17.5	25.0
16	17	32	18	41	20	44	10	22	17.5	25.0
17	17	32	18	41	20	44	10	22	17.5	26.0

Note. Values L = lower boundary; U = upper boundary.

Minimal general values for percent fat and body mass index are adapted, with permission, from The Cooper Institute, 2004, *FITNESSGRAM/ACTIVITYGRAM Test Administration Manual*, 3rd edition (Champaign, IL: Human Kinetics), 61, 62.

Preferred general values for percent body fat and body mass index and skinfold values are from *The Brockport Physical Fitness Test Manual*, p. 61, by J. Winnick & F. Short, 1999. Champaign, IL: Human Kinetics. Reprinted with permission.

The intercepts for the males were extrapolated to age from stages of maturity based on values provided in Lohman (1992; T.G. Lohman, personal communication, January 12, 1998). Coefficients of determination ranged from .76 – .82 and standard errors of estimate varied from 3.2 – 3.8% body fat as a function of maturity level among 8-18 year-old subjects when the TS skinfold equations were used to predict percent body fat from a multicomponent model (Slaughter et al., 1998).

TO standards were calculated by Lohman (T.G. Lohman, personal communication, March 7, 1997 and May 16, 1997) and provided directly to Project Target staff for use in the BPFT. He determined percentile ranks for both BMI

Table 1b Preferred General Standards for Measures of Body Composition

	% Fat P		Triceps plus Subscap. Skinfold (mm.) P		Triceps plus Calf Skinfold (mm.) P		Triceps Skinfold (mm.) P		Body Mass Index P	
Males										
Age	U	L	U	L	U	L	U	L	U	L
10	10	20	11	22	12	26	7	16	15.3	20.0
11	10	20	12	23	12	26	7	16	15.8	20.0
12	10	20	13	24	12	26	7	16	16.0	20.5
13	10	20	13	24	12	26	7	15	16.6	22.0
14	10	20	14	25	12	26	7	15	17.5	23.0
15	10	20	14	25	12	26	7	14	18.1	24.0
16	10	20	15	26	12	26	7	14	18.5	25.0
17	10	20	15	26	12	26	7	14	18.8	25.5
Females										
10	17	25	18	30	20	33	10	19	16.6	21.5
11	17	25	1	30	20	33	10	19	16.9	22.0
12	17	25	18	30	20	33	10	19	16.9	23.0
13	17	25	18	30	20	33	10	19	17.5	23.0
14	17	25	18	30	20	33	10	19	17.5	23.0
15	17	25	18	30	20	33	10	19	17.5	23.0
16	17	25	18	30	20	33	10	18	17.5	23.5
17	17	25	18	30	20	33	10	18	17.5	23.5

Note. Values L = lower boundary; U = upper boundary.

and triceps-only skinfold measures using data from the National Children and Youth Fitness Study (Gold, 1985). The TO standards have percentile ranks that correspond to the same percentile ranks for each of the previously established BMI standards.

The TO standards fluctuate somewhat with age. TO standards associated with the larger percent body fat values that define the ranges for both minimal and preferred standards (i.e., 20% and 25% for boys; 25% and 32% for girls) decline slightly with age. This decline reflects the changes in fat distribution that occur during adolescence; that is, a greater proportion of body fat accumulates in the trunk relative to the extremities with increasing age in adolescence. The standards associated with the smallest percent body fat values that define the ranges for both minimal and preferred standards (i.e., 10% for boys; 17% for girls), however, remain constant throughout the 10-17 age range. These TO standards do not decline with age because the proportion of trunkal fat does not increase with age among leaner adolescents (T.G. Lohman, personal communication, October 22, 1997).

Of particular significance is that no specific standards for any recommended or optional measure of body composition are provided in the BPFT; that is, regardless of disability, youngsters are expected to achieve the same skinfold (or body mass index) standards that are recommended for youngsters without disabilities. Although previous research has reported significantly larger skinfold values for participants with mental retardation (Rarick, Dobbins, & Broadhead, 1976; Rarick & McQuillan, 1977), and visual impairment, spinal neuromuscular conditions, and congenital anomalies, and amputations (Winnick & Short, 1982) when compared to participants without disabilities, no literature was found to suggest that these larger values should be considered acceptable. While a sedentary lifestyle, a frequent correlate of disability, helps to explain larger skinfolds in youngsters with disabilities, it does not justify it. To the contrary, excessive body fat, in its own right, represents a significant health-related concern for persons with disabilities and may exacerbate other disability-related conditions as well. In a national 20-year longitudinal survey with over 6,800 adult participants, Ferraro, Su, Gretebeck, Black, and Badylak (2002) found that the presence of obesity at the start of the study, or the acquisition of obesity during the study, was later associated with higher levels of disability (especially in the lower body). Although it may be more difficult for certain youngsters with disabilities to achieve the general skinfold standards than their nondisabled peers, it may be more important that they do so.

Using regression equations developed on participants without disabilities for predicting percent body fat in people with physical disabilities has been questioned (Shephard, 1990). Rimmer (1994), however, has reported that equations developed from upper body skinfolds have been used in investigations using participants with SCI. He acknowledges that while these equations may be less accurate for those with SCI, "using them as a general index of fatness is acceptable" (Rimmer, 1994, p. 224). More recently, a team of Italian researchers using dual x-ray absorptiometry and skinfolds found that the skinfold method significantly underestimated fat mass in a group of 13 participants with SCI. They concluded that predictive equations developed for persons without disability appear to be inapplicable to people with SCI (Maggioni et al., 2003). In the absence of widely accepted alternative equations for persons with disabilities, however, the equations developed by Lohman and colleagues for people without disabilities have been adopted for use in the BPFT. It is possible, therefore, that some additional error may be operative in predicting percent body fat in youngsters with physical disabilities. As a result, testers may prefer to interpret skinfold results directly in terms of the size of the fold rather than in terms of percent body fat, but either way, the skinfold standards are not adjusted for disability.

Attainability To determine if the minimal BPFT skinfold standards were within reach of youngsters with disabilities, they were applied to TS data previously collected during Project UNIQUE (Winnick & Short, 1982). Passing rates for youngsters with cerebral palsy, spinal neuromuscular conditions (consisting primarily of participants with SCI), blindness, and congenital anomalies or amputations are summarized in Table 2.

Passing rates (denoted by values "within zone") vary from 52% for boys with spinal neuromuscular conditions to 80% for girls with CA/A. It would appear from these data that the standards will present the greatest challenge to youngsters with

Table 2 Pass Rates for Youngsters with Disabilities on Sum of Triceps and Subscapular Skinfolds

		Below Zone		Within Zone*		Above Zone	
	Total N	N	%	N	%	N	%
Cerebral Palsy							
Boys	207	37	18	134	65	36	17
Girls	173	49	28	111	64	13	8
Spinal Neuromuscular							
Boys	67	4	6	35	52	28	42
Girls	72	13	18	42	58	17	24
Blind							
Boys	82	13	16	58	71	11	13
Girls	76	14	18	47	62	15	20
Congenital Anomaly/ Amputation							
Boys	35	5	14	19	54	11	31
Girls	25	3	12	20	80	2	8
Combined							
Boys	391	59	15	246	63	86	22
Girls	346	79	23	220	64	47	14
Total	737	138	19	466	63	133	18

*defined by the upper and lower boundaries provided in Table 1.

Note. Data from *Project UNIQUE: Physical fitness testing of the disabled*, by J. Winnick & F. Short, 1985. Champaign, IL: Human Kinetics. Used with permission.

SCI; approximately one-third of all youngsters with spinal neuromuscular conditions tested during Project UNIQUE were above the minimal range. This finding is not surprising since people with less active muscle mass will have a lower potential for caloric expenditure. In essence, the mode of exercise is reduced to arms-only activities rather than "whole-body" activities, which generally are recommended for weight loss. Many youngsters with SCI pursuing the TS standards will need to counter the "reduction" in exercise mode by increasing exercise frequency and/or duration.

It is interesting to note that more girls with CP were below the range than above it. Being below the range, however, probably is a less serious concern for those with CP since certain characteristics of the disability (e.g., hypertonicity, spasticity, inefficiency of movement) probably contribute more to a youngster's leanness than poor diet or nutrition, or other correlates of leanness that are associated with negative health.

Looney and Plowman (1990) determined passing rates for youngsters without disability on the original (1987) FITNESSGRAM skinfold measures. In the original version, percent body fat standards were provided only for the upper values in the range (i.e., 25% for boys and 32% for girls). Using TS data from the National

Children and Youth Fitness Study (I and II), they found passing rates of 89% for the males and 91% for the females. So, the percentage of youngsters who were above the range in their analysis varied from 9-11%. These values certainly are lower than the "above zone" values appearing in Table 2. Nevertheless, the majority (63%) of youngsters with disabilities from Project UNIQUE were able to meet the minimal standards, and it is reasonable to assume that with increased attention to body composition, an additional number of their peers could do so as well.

Without access to a skinfold database for youngsters with MR, a determination of pass/fail rates was not possible for this manuscript. Some evidence of attainability, however, was provided by the norm-referenced data reported by Eichstaedt, Wang, Polacek, and Dohrmann (1991). These data suggest that the triceps-only skinfolds of boys with moderate mental retardation will exceed the minimal standards (i.e., will be "above zone") in approximately 21% of the cases. For girls with moderate retardation, it appears that the standards may be more difficult to achieve as the triceps standards were exceeded (i.e., "above zone") about 30% of the time in the Eichstaedt et al. (1991) data. Still, it appears that the standards are within reach for many youngsters with mental retardation and mild limitations in fitness.

Body Mass Index

Body mass index is calculated by dividing a person's weight (in kilograms) by the square of their height (in meters). BMI provides an indication of the appropriateness of one's weight relative to height; it does not, however, provide a very accurate estimate of percent body fat. Correlations between BMI and percent body fat reported in the literature range from .70 to .82 for adults (Lohman, 1992), values which are lower than those reported for skinfolds. Perhaps of greater concern, however, is the finding that standard errors of estimate associated with the prediction of percent body fat from BMI data tend to be higher (and in some cases, considerably higher) than those utilizing skinfold data (Lohman, 1992). High BMI values, therefore, are more appropriately considered to be indications of being "overweight" rather than "obese." "Although most overweight people are also obese, it is possible to be obese without being overweight (i.e., sedentary individuals with a small muscle mass) and overweight without being obese (i.e., body builders and certain athletes)" (VanItallie & Lew, 1992, p. 5). For these reasons, BMI is an optional rather than recommended measure of body composition in the BPFT. (The BMI is not suggested for use with youngsters with SCI or CA/A.)

Although BMI does not measure percent body fat very accurately, it is a health-related measure of body composition. High BMI scores are related to increased mortality rates, and the risk increases proportionately with increasing BMI (Lohman, 1994). High BMI also has been linked to the increased risk of developing hypertension, hypercholesterolemia, cardiovascular disease, non-insulin-dependent diabetes, certain cancers, and other medical problems (Lohman, 1992). There also is evidence that a higher BMI value (> 75th percentile) in adolescence translates to greater relative risk of all-cause mortality and coronary heart disease mortality in adulthood when compared to lower (between the 25th and 50th percentiles) adolescent BMI values (Solomon, Willett, & Manson, 1995).

Very low BMI values also have been linked to higher all-cause mortality rates (Skinner & Oja, 1994). The significance of this relationship, however, is not completely understood since there is contradictory evidence suggesting that the risk of mortality does not increase among those with the lowest BMIs (Lindsted, Tonstad, & Kuzma, 1991) and because of the suggestion that any relationship between low BMI and mortality may be the result of other concomitant relationships. "The excess risks of being underweight appear to be largely, if not entirely, artifactual due to inadequate control of confounding by chronic or subclinical illness and/or cigarette smoking" (Solomon et al., 1995, p. 9). So, any relationship that might exist between low BMI and increased risk of mortality may really be due to illness or smoking, conditions which would contribute to lowering BMI while increasing the risk of mortality.

Standards Unlike most of the skinfold standards, the BMI standards fluctuate with age (see Table 1). Since the BMI includes the weight of muscle and bone (in addition to fat), it is apparent that BMI values will increase during the developmental period. In order to determine BMI standards for the FITNESSGRAM, Lohman (1994), using the NCYFS data, developed individual regression equations for males and females aged 6-17. These equations were used to identify BMI values that correspond to 10 and 25% body fat in males and 17 and 32% body fat in females, the same criteria used for the skinfold standards. These BMI values serve as the minimal standards in the BPFT. Using the same regression equations, Lohman (T.G. Lohman, personal communication, May 16, 1997) calculated BMI standards for 20% body fat in males and 25% in females to serve as the basis for the preferred standards in the BPFT. As with the skinfold measures, no specific standards are recommended for youngsters with disabilities.

Attainability Pass/fail rates for the minimal standards for BMI were calculated for males and females with cerebral palsy or blindness who were part of the Project UNIQUE data base (Winnick & Short, 1982). These results are summarized in Table 3. Pass rates (defined as "within zone") ranged from 47% for boys with CP to 68% for boys who are blind. Overall, 53% of all youngsters with CP and 65% of all youngsters with blindness in the 1982 sample met the BMI standards. Using more recently collected data, Lieberman and McHugh (2001) reported a 47% pass rate on BMI (using the same standards) for youngsters with blindness (and reported

Table 3 Pass Rates for Youngsters With Disabilities on BMI

		Below Zone		Within Zone*		Above Zone	
	Total N	N	%	N	%	N	%
Cerebral Palsy							
Boys	209	83	40	98	47	28	13
Girls	170	48	28	102	60	20	12
Blind							
Boys	82	15	18	56	68	11	13
Girls	77	12	16	48	62	17	22

*defined by the upper and lower boundaries provided in Table 1.

Note. Data from *Project UNIQUE: Physical fitness testing of the disabled*, by J. Winnick & F. Short, 1985. Champaign, IL: Human Kinetics. Used with permission.

a 76% pass rate for youngsters with low vision). It appears that the standards for BMI are within reach for many youngsters with CP or blindness.

In comparing the pass/fail rates for youngsters with CP or blindness on BMI with the corresponding values on TS skinfolds, it is interesting to note that the percentages for each category do not vary by more than a few percentage points except in the case of boys with CP. For this group, the differences are more dramatic. Twenty-two percent more males with CP were identified as "below zone" (i.e., underweight) using BMI as opposed to TS skinfolds. An accurate assessment of height is sometimes difficult to determine when a youngster's posture is characterized by exaggerated flexor tone, as is the case with some youngsters with CP. The tendency, however, would be that measuring stature (i.e., standing height without regard to flexed knees or hips) rather than body length (i.e., measuring body segments and summing the parts) would result in smaller values for "height" in the BMI equation. If height is underestimated, however, BMI will be overestimated and that certainly does not appear to be the case with boys with CP. Explaining these differences becomes even more difficult when it is noted that the percentages in each category for the girls with CP are quite similar for BMI and TS skinfolds. It appears that more work will need to be conducted to better understand the skinfold and BMI pass rate differences for boys with CP. It may be that more boys with CP are "underweight" than are excessively "lean," suggesting that a BMI-based body composition intervention program should include muscle development since increased musculature will also tend to raise BMI. In the meantime, testers should realize that the body composition pass rates for males with CP may be higher with TS skinfolds than with BMI (although the "above zone" rates should be similar).

Looney and Plowman (1990) investigated the passing rates of children and youth without disabilities on the original (1987) FITNESSGRAM standards for BMI using scores from the NCYFS. They reported passing rates of 88% for the males and 85% for the females, but it is important to note that the original standards generally were more rigorous (i.e., required lower BMI values) than the current FITNESSGRAM standards. It is also important to remember that the original FITNESSGRAM only provided a single standard (at the high end of the scale) rather than a range of scores, so it was not possible for youngsters to fail because they were too light for their height.

In an effort to place the attainability of BMI standards of youngsters with MR into some context, we used the median height and weight data of participants with moderate mental retardation as reported by Eichstaedt et al. (1991). BMI values were calculated for both males and females across the 10-17 age range using median height and weight values. In all cases, the resultant BMI fell within the range of the minimal standards associated with BPFT. Although such an analysis does not provide specific pass/fail rates, it does suggest that the standards are within reach of youngsters with MR and mild limitations in fitness.

Reliability

Test-retest reliability of various skinfold measures has been shown to be high. Lohman (1994) reported that reliability coefficients generally exceed .90 in studies that have investigated intrarater reliability (i.e., the precision of several measures taken at the same sites by the same tester). A number of others have addressed the

Table 4 Intrarater Reliability of Skinfold Measures Using Participants With Disabilities

Author	Disability	N	Gender	Age	Field Test	Reliability Coefficient
Reid, Montgomery, & Seidl (1985)	MR	20	M/F	20-39	percent body fat from triceps, biceps, subscapular, and supra-iliac	R = .95
Rarick & McQuillan (1977)	TMR	102	M/F	11-15	triceps, subscapular, calf	r = .91 – .99
Pizarro (1990)	MR	81	M/F	12-15	triceps	r = .98 – .99
Daquila (1982)	VI	50	M/F	10-17	triceps, subscapular, abdominal	a = .99 (all sites)
	AI	50	M/F	10-17		a = .90 – .99
	OI	50	M/F	10-17		a = .97 – .99

Note. r = interclass coefficient; R = intraclass coefficient; a = alpha coefficient; TMR = trainable mentally retarded; AI = auditory impaired; OI = orthopedically impaired.

reliability of skinfold measures when persons with disabilities served as participants. These studies are summarized in Table 4. Reliability coefficients reported in these investigations have also been high, ranging from .90 – .99.

Results of studies that have investigated interrater reliability of skinfold testing (i.e., the precision of several measures taken at the same sites by different testers) suggest a greater source of error compared to intrarater reliability (Lohman, 1994). At least some of the error attributed to interrater reliability appears to be due to differences in training methods. Lohman (1994) suggested that interrater reliability can be improved by using videotapes to standardize the training of testers and recommended that testers view such a tape prior to collecting skinfold data. Jackson, Pollock, and Gettman (1978) reported intraclass Rs of .98 for the means of both triceps and subscapular skinfolds from 35 participants as measured by three testers. They reported standard errors of 1.82 for triceps and 2.25 for subscapular folds.

Due to the objective nature of the measurements that comprise body mass index, reliability is not as serious a concern for this test of body composition. "The reliability of BMI is very high because the measurement of height and weight is very precise when following a standardized protocol" (Lohman, 1994, p. 59).

Discussion

For measures of body composition, validity was established primarily from the concurrent and predictive properties of the skinfold and BMI tests. Concurrent validity is claimed for skinfolds in part because of their relationship to percent body fat, which in turn has been found to be related to health problems. BMI, although it does not measure percent body fat, has been shown to be directly related to health problems and is also related to skinfolds. Predictive validity of the skinfold tests lies in their ability to reasonably estimate both percent body fat and BMI values through multiple regression techniques.

Although the information presented in this manuscript is meant to suggest that the measures of body composition included in the BPFT have both sufficient validity and reliability for use with youngsters with disabilities, the need for additional research remains. Some ideas for future research in this area include the following:

- Determine the accuracy of body fat prediction equations developed on participants without disabilities for youngsters with CP or SCI;
- Further investigate the relationship between BMI and skinfolds for boys with CP (i.e., Why did twice as many boys with CP from the Project UNIQUE data fall "below zone" on BMI compared to TS skinfolds?);
- Determine pass/fail rates for youngsters with MR on both skinfolds and BMI;
- Determine pass/fail rates for youngsters with VI on TC skinfolds;
- Determine the "decision validity" of the skinfold tests (i.e., Can skinfolds accurately classify individuals as obese when the criterion for obesity is established through hydrostatic weighing, dual energy x-ray aborptiometry, or other more sophisticated techniques?);

- Determine the "consistency of classification" (a measure of criterion-referenced reliability) for skinfolds and BMI (e.g., If a youngster is classified as "too lean" on one administration of a skinfold test, will he/she be classified the same way on a subsequent administration of the test?).

It is quite possible that future research may eventually alter some of the body composition standards associated with the BPFT. The rationale for the items, however, appears strong and it seems that both skinfolds and body mass index have a role to play in the assessment of health-related physical fitness in youngsters with disabilities.

References

American Alliance for Health, Physical Education, Recreation, and Dance. (1980). *The health related physical fitness test manual.* Reston, VA: Author.

Cooper Institute for Aerobics Research. (1992). *Prudential FITNESSGRAM test administration manual.* Dallas, TX: Author.

Cooper Institute for Aerobics Research. (1999). *FITNESSGRAM test administration manual.* Dallas, TX: Author.

Cooper Institute for Aerobics Research. (2004). *FITNESSGRAM/ACTIVITYGRAM test administration manual.* Dallas, TX: Author.

Daquila, G.A. (1982). *Reliability of selected health and performance related test items from the project UNIQUE Physical Fitness Test Inventory.* Unpublished master's thesis, State University of New York, Brockport.

Eichstaedt, C.B., Wang, P.Y., Polacek, J.J., & Dohrmann, P.F. (1991). *Physical fitness and motor skill levels of individuals with mental retardation: Mild, moderate, and Down Syndrome, ages 6-21.* Normal, IL: Illinois State University.

Ferraro, K., Su, Y-P., Gretebeck, R., Black, D., & Badylak, S. (2002). Body mass index and disability in adulthood: A 20-year panel study. *American Journal of Public Health,* **92**, 834-840.

Gold, R. (1985). *Summary of findings from National Children and Youth Fitness study.* Washington, DC: U.S. Department of Health and Human Services.

Hoelscher, D., Day, R., Lee, E., Frankwoski, R., Kelder, S., Ward, J., & Schever, M. (2004). Measuring the prevalence of overweight in Texas schoolchildren. *American Journal of Public Health,* **94**, 1002-1008.

Jackson, A.S., Pollock, M.L., & Gettman, L.R. (1978). Intertester reliability of selected skinfold and circumference measurements and% fat estimates. *The Research Quarterly,* **49**, 546-551.

Lieberman, L., & McHugh, E. (2001). Health-related fitness of children who are visually impaired. *Journal of Visual Impairment & Blindness,* **95**, 272-287.

Lindsted, K., Tonstad, S., & Kuzma, J.W. (1991). Body mass index and patterns of mortality among seventh-day Adventist men. *International Journal of Obesity,* **15**, 397-406.

Lohman, T.G. (1992). *Advances in body composition assessment.* Champaign, IL: Human Kinetics.

Lohman, T.G. (1994). Body composition. In J.R. Morrow, H.B. Falls, & H.W. Kohl (Eds.), *The Prudential FITNESSGRAM technical reference manual* (pp. 57-72). Dallas, TX: The Cooper Institute for Aerobics Research.

Looney, M.A., & Plowman, S.A. (1990). Passing rates of American children and youth on the FITNESSGRAM criterion-referenced physical fitness standards. *Research Quarterly for Exercise and Sport,* **61**, 215-233.

Maggioni, M., Bertoli, S., Margonato, V., Merati, G., Veicsteinas, A., & Testotin, G. (2003). Body composition assessment in spinal cord injury subjects. *Acta Diabetologica*, **40**, s1, 183-186.

McSwegin, P., Pemberton, C., Petray, C., & Going, S. (1989). *Physical best: The AAHPERD guide to physical fitness education and assessment.* Reston, VA: AAHPERD.

Pizzaro, D.C. (1990). Reliability of the health related fitness test for mainstreamed educable and trainable mentally handicapped adolescents. *Adapted Physical Activity Quarterly*, **7**, 240-248.

Rarick, G.L., Dobbins, D.A., & Broadhead, G.D. (1976). *The motor domain and its correlates in educationally handicapped children.* Englewood Cliffs, NJ: Prentice-Hall.

Rarick, G.L., & McQuillan, J.P. (1977). *The factor structure of motor abilities of trainable mentally retarded children: Implications for curriculum development final report.* Project No. H23-2544. Department of Health, Education, and Welfare, Office of Education Bureau of Education for the Handicapped. Berkeley, CA: University of California, Department of Physical Education.

Reid, G., Montgomery, D.L., & Seidl, C. (1985). Performance of mentally retarded adults on the Canadian Standardized Test of Fitness. *Canadian Journal of Public Health*, **76**, 187-190.

Rimmer, J.H. (1994). *Fitness and rehabilitation programs for special populations.* Madison, WI: Brown & Benchmark.

Rush, S., (2004). Obesity: America's growing epidemic. *Health& Fitness Journal*, **8**(6), 25-27.

Shephard, R.J. (1990). *Fitness in special populations.* Champaign, IL: Human Kinetics.

Skinner, J.S., & Oja, P. (1994). Laboratory and field tests for assessing health-related fitness. In C. Bouchard, R.J. Shephard, & T. Stephens (Eds.), *Physical activity, fitness, and health* (pp. 160-180). Champaign, IL: Human Kinetics.

Slaughter, M.H., Lohman, T.G., Boileau, R.A., Horswill, C.A., Stillman, R.J., VanLoan, M.D., & Benben, D.A. (1988). Skinfold equations for estimation of body fatness in children and youth. *Human Biology*, **60**, 709-723.

Solomon, C.G., Willett, W.C., & Manson, J.E. (1995). Body weight and mortality. In T.B. VanItallie & A.P. Simopoulos (Eds.), *Obesity: New directions in assessment and management* (pp. 1-11). Philadelphia: Charles Press.

VanItallie, T.B. & Lew, E.A. (1992). Assessment of morbidity and mortality risk in the overweight patient. In T.A. Wadden & T.B. VanItallie (Eds.), *Treatment of the seriously obese patient* (pp. 3-32). New York: Guilford Press.

Williams, D.P., Going, S.B., Lohman, T.G., Herska, D.W., Srinivasan, S.R., Webber, L.S., & Berenson, M.D. (1992). Body fatness and risk for elevated blood pressure, total cholesterol and serum lipoprotein ratios in children and adolescents. *American Journal of Public Health*, **82**, 358-363.

Winnick, J.P., & Short, F.X. (1982). *The physical fitness of sensory and orthopedically impaired youth: Project UNIQUE final report.* (Project No. 023H10058). Special Education Programs, U.S. Department of Education. Brockport, NY: State University of New York, Brockport. (ERIC ED 240764).

Winnick, J.P., & Short, F.X. (1985). *Physical fitness testing of the disabled: Project UNIQUE.* Champaign, IL: Human Kinetics.

Winnick, J.P., & Short, F.X. (1999). *The Brockport Physical Fitness Test.* Champaign, IL: Human Kinetics.