DERLEME REVIEW

DOI: 10.5336/healthsci.2022-93841

Evaluation of Body Composition in Disabled People: A Traditional Review

Engelli Bireylerde Vücut Bileşiminin Değerlendirilmesi: Geleneksel Derleme

Merve Esra ÇITAR DAZIROĞLU[a], Eda KÖKSAL[a]

[a]Department of Nutrition and Dietetics, Gazi University Faculty of Health Sciences, Ankara, Türkiye

ABSTRACT Anthropometric measurements and laboratory methods allow the determination of body sizes and composition of individuals. In this way, it is possible to evaluate the nutritional status of people and to intervene. However, sometimes the body composition can be difficult to assess, and one of them is disability. The term of disability is used to describe the individual who is affected by the attitudes and environmental conditions that restrict their full and effective participation in equal conditions with other individuals due to their loss of physical, mental, spiritual, and sensory abilities at various levels. Although the disabled can be examined under different subgroups, there are all difficulties when considering the anthropometric measurement and laboratory methods used for nutritional use in orthopedically and mentally disabled patients from these groups. For example, limb loss in amputation, postural disorders in cerebral palsy and spinal deformities, and different growth and development in cerebral palsy and Down syndrome make it difficult to evaluate the body composition of these disabled groups. For this reason, various equations have been developed for these groups, specific to the disability group. At the same time, there are group-specific growth curves in groups with different growth and development. For this reason, the characteristics of the disabled group should be well known and the right decision should be made on the methods to be used for the alternative and a path should be followed accordingly. In this review, 4 disability groups, namely amputation, cerebral palsy, spinal deformities, and Down syndrome, are discussed.

Keywords: Disabled persons; body composition; anthropometry

ÖZET Antropometrik ölçümler ve laboratuvar yöntemleri, bireylerin vücut ölçülerinin ve kompozisyonlarının belirlenmesine olanak sağlar. Bu sayede, kişilerin beslenme durumlarını değerlendirmek ve müdahale etmek mümkündür. Ancak bazen vücut bileşiminin değerlendirilmesi zor olabilir ve bunlardan biri de engellilik durumudur. Çeşitli şekillerde tanımlanan engellilik terimi; farklı düzeylerdeki bedensel, zihinsel, ruhsal ve bedensel kayıplarından dolayı diğer bireylerle eşit koşullarda tam ve etkin katılımın kısıtlandığı bireyi tanımlamak için kullanılmaktadır. Engelliler farklı alt gruplar altında incelenebilmekle birlikte, bu gruplardan özellikle ortopedik ve zihinsel engelli olan bireylerde beslenme durumunun değerlendirilmesi amacıyla kullanılacak antropometrik ölçüm ve laboratuvar yöntemlerinin değerlendirilmesinde çok çeşitli zorluklar mevcuttur. Örneğin ampütasyonda uzuv kaybı olması, serebral palsi ve spinal deformitelerde postür bozukluğunun olması, serebral palsi ve Down sendromunda ise akranlarından farklı büyüme ve gelişmenin gerçekleşmesi, bu engelli grupların vücut bileşiminin değerlendirilmesini zorlaştırmaktadır. Bu nedenle bu gruplara yönelik olarak, engel grubuna özel olacak şekilde çeşitli denklemler geliştirilmiştir. Aynı zamanda, farklı büyüme ve gelişme görülen gruplarda da gruba özel büyüme eğrileri bulunmaktadır. Bu nedenle engelli grubun özellikleri iyi bilinmeli ve alternatif için kullanılacak yöntemlere doğru karar verilerek ona göre bir yol izlenmelidir. Bu derlemede, ampütasyon, serebral palsi, spinal deformiteler ve Down sendromu olmak üzere 4 engelli grubu tartışılmıştır.

Anahtar Kelimeler: Engelli bireyler; vücut bileşimi; antropometri

Anthropometry is the measurement of weight, body size, and proportions, and it is a precious adjunct in assessing nutritional status. Anthropometric measures can be used to evaluate nutritional status both in cases of emaciation caused protein-energy malnutrition and obesity caused by overnutrition.[1] For all that, it is not always possible to apply these methods to all individuals, and one of them is the disabled group. In the literature, the terms impairment, disability, and handicap are frequently used interchangeably for individuals with physical deficiencies. However, there is no consensus and meaning unity in

Correspondence: Merve Esra ÇITAR DAZIROĞLU
Department of Nutrition and Dietetics, Gazi University Faculty of Health Sciences, Ankara, Türkiye
E-mail: esracitar@gmail.com

Peer review under responsibility of Turkiye Klinikleri Journal of Health Sciences.

Received: 16 Nov 2022 ***Received in revised form:*** 03 Jan 2023 ***Accepted:*** 12 Jan 2023 ***Available online:*** 25 Jan 2023

the literature for these terms. Therefore, determining the definitions and ensuring clarity is the priority in studies on the subject.[2] In 1981, the World Health Organization (WHO) defined these terms as follows.[3]

Impairment is any loss or abnormality of a psychological, physiological, or anatomical function or structure. Disability is any restriction or lack of ability to perform an activity in the manner or within the range considered normal for a human being. And handicap is a disadvantage for a given individual, resulting from an impairment or a disability, that prevents or limits the fulfillment of a role that is normal for that individual.

Anthropometric measurements and laboratory methods have an important role in the evaluation of nutritional status in disabled individuals; however, there are some difficulties in measurements (Figure 1). Therefore, in order to make the correct measurement, it is significant to determine the characteristics of the group and the methods to be used. This review is handled with the aim of examining an anthropometric measurement and laboratory methods used to evaluate body composition in individuals with disabilities and guide researchers.

AMPUTATION

Amputation derived from the Latin word "amputare" (excision, cutting out) is defined as "removing some or all of a body surrounded by the skin."[4] This anatomical loss also brings with the loss caused by function, change in body weight distribution, coordination disorder and psychosocial disorders.[5] However, there are some difficulties in measuring the height and body weight within the scope of evaluation of nutritional status in these individuals.

Although height measurement is possible to some extent in individuals with unilateral amputation, it is difficult to measure the correct body weight since the loss of body weight due to limb amputation. In people with bilateral limb amputation, it is not possible to take height measurements since both lower-limbs are absent. Varied efforts were made to develop some methods to measure the height of these individuals, but adequately no standardized method could be developed.[6]

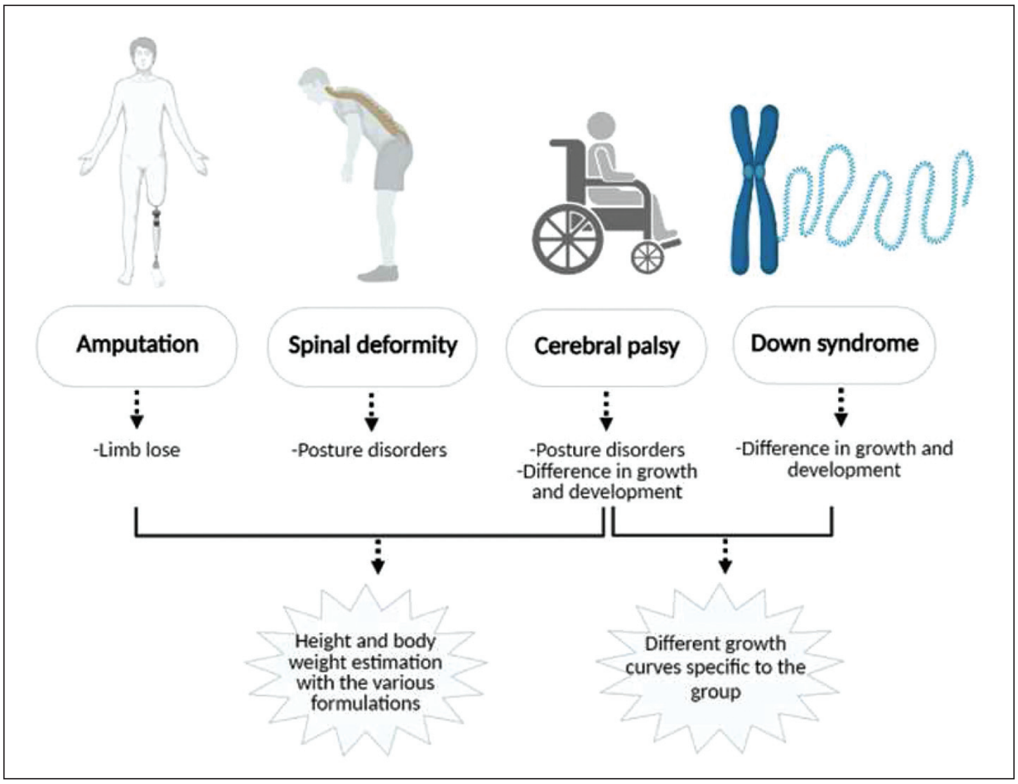

FIGURE 1: Summary of some features that prevent taking anthropometric measurements in people with disabilities.

In estimating the height of amputees, the arm span can be used. The use of arm span is recommended as an suitable measure for height estimation in clinical situations where it is problematic to measure standing height limited by quadriplegia, amputation, scoliosis, existing osteoporotic fractures, paraplegia, or coma.[7] In addition, ulna length, knee height, sitting height, tibia length are also alternative anthropometric measurements that can be used in height estimation.[8-11]

For the determination of the current body weight of an amputation patient, adjustments can be made by taking the estimated weight of the amputated body part into account.[1] The percentages of the contribution of some body parts to the total body weight according to different sources are shown in Table 1.[12,13] When the values are placed in the required formulations using these values, it can be estimated what the body weights would be without amputation.[1] Osterkamp, in his review published in 1995, stated the proportions of the segments of the body, and these proportions are used by many researchers.[13]

According to the recommendations of the Amputee Coalition, the ratio of the body segments is different from Osterkamp (Table 1).[12,13] Estimated body weight according to these proportions is calculated by the formula below.

Estimated body weight formula:[14]

- $Wt_E = Wt_O/(1-P)$

Wt_E: Estimated body weight

Wt_O: Observed body weight

P: Percentage of total body weight of missing limb

TABLE 1: Estimated percentage in total body mass of amputation levels according to Osterkamp and Amputee Coalition.[12,13]

	Estimated percentage of total body mass	
Amputation level	**Osterkamp**	**Amputee Coalition**
Hemipelvectomy/hip disarticulation	16	11.83
Above-knee	10.1	9.96
Below-knee	5.9	3.26
Shoulder disarticulation	5	5.00
Above-elbow	2.7	3.55
Below-elbow	2.3	1.45
Foot	1.5	1.30
Hand	0.7	0.70

If the limb loss weight is not taken into account when calculating body mass index (BMI) in individuals with amputation, BMI values are found lower compared to healthy individuals without amputation. Therefore, it is necessary to use the estimated body weight in order to prevent the underestimation of nutritional status in people with limb amputation. Thus, BMI can be used reliably for people with limb amputation.[6] According to the Amputee Coalition, when calculating BMI in amputated individuals, the first step is to obtain the estimated body weight using the formula $Wt_E=Wt_O/(1-P)$, and then to use a regulated formulation for the estimated BMI value. Assessment of the estimated BMI value obtained is not different from normal healthy adult individuals.

Formulation created for estimated BMI value:

- Estimated BMI=estimated body weight/height[12]

Besides all these, calculating BMI becomes a complicated situation since additional measurements and corrections are required to take into account because of the weight of limbs lost in amputated individuals. Therefore, it has been stated that upper arm anthropometry may be a more useful indicator than BMI for the people with unilateral lower limb amputation regarding nutritional health and outcomes.[15]

Mid-upper arm circumference (MUAC) is a practical tool that is a good indicator of nutritional status in adults, and MUAC≥24.3 cm is considered normal, and MUAC<24.3 cm is considered as a chronic energy deficiency.[6,16] In adults, mid upper arm muscle area (UAMA) is associated with total body muscle mass.[17] UAMA is especially valuable in the evaluation of edematous individuals and amputated individuals whose body weights increase with increasing intracellular fluids. It is calculated using triceps skinfold thickness (TSF) and MUAC.[1] Compared to the UAMA measured by computed tomography (CT), the UAMA estimates obtained as a result of the UAMA equation showed that the equation gave the UAMA 20-25% more. Therefore, Heymsfield et al. revised the equation, and they proposed the following equation to find a result closer to the true UAMA value:[17]

- UAMA (m^2)=[$[MUAC-(TSF)]^2/4\pi$]-6.5→ female

- UAMA (m^2)=[[MUAC-(TSF)]^2/4π]-10→ male

Various changes also occur in the body composition of amputated individuals. Muscle atrophy is common due to bed rest after amputation, changes in walk, and loss of the ability of the limb to contract strongly.[18] In the assessment of the body composition in amputated individuals, DEXA was used in one study, and in another study, a bioelectrical impedance analysis (BIA) with a multifrequency and 4 electrodes, was used.[19,20] In another study, the researchers used a multifrequency BIA and stated that the proximal current injection electrode and the proximal voltage detection electrode should be at least 25 cm away.[21] Also, if there is a condition or feature that would limit the placement of electrodes on the body surface, like amputation, the electrodes should be fixed to an uninfluenced body part.[22]

CEREBRAL PALSY

Cerebral palsy (CP) is a permanent disorder in movement and posture development which causes limitation of activity due to non-progressive disorders occurring in the infant or developing fetal brain.[23]

There are 2 main difficulties in assessing growth in children with CP. Firstly, children may have muscle weakness, joint contractures, involuntary movements, and/or scoliosis that make it difficult to stand or stand straight even if it is not impossible, and therefore an accurate and reliable height length measurement may not always be possible. Secondly, accordingly atypical growth models, the generally accepted reference curves for typically developing children may not be suitable for use in children with CP.[24] Because of such difficulties, accurate weight and height measurement often causes difficulties in children with severe motor disorders.[25]

Due to the difficulties in height measurement, tibial length, upper arm length (UAL) and knee height are the suitable alternative measurements that can be used to estimate height.[25,26] The uses of these measurements are valid and reliable.[24] Equations used to predict height by knee height, UAL, and tibial length in children with CP were developed based on data obtained from 172 children with CP 48% of whom were non-ambulatory, between the ages of 2-12, and these equations are shown below.[27]

- UAL → Height=21.8 (Standard error 1.7 cm)+(4.35 x UAL)
- Tibial length (TL)→Height=30.8 (Standard error 1.4 cm)+(3.26 x TL)
- Knee height (KH)→Height=24.2 (Standard error 1.1 cm)+(2.69 x KH)

The use of arm span in the prediction of length in CP is also among the basic alternatives; however, arm span may not be used in patients with muscular dystrophy because they also have elbow and shoulder contractures or cannot extend their arms completely due to their weaknesses. Therefore, it has been emphasized that for children with unstoppable finger or wrist contractions, ulna length measurement can be used in height estimation.[28] There is a formula developed between 5-19 years old for the prediction of height from ulna length. Height for men (cm)=(1.308 x age)+(4.605 x ulna length)+28.003; height for girls (cm)=(1.315 x age)+(4.459 x ulna length)+31.485.[8]

All anthropometric measurements should be taken on the left side of the body to assess growth in children, and interpretations should use the average of 2 measurements. In cases where repeats are not at acceptable levels of accuracy, a third measurement may be taken, and the 2 closest measurements used can be averaged. In children with CP with significant asymmetry, it is recommended to take measurements from the less impaired side.[10] For the children who cannot sit independently, the proper position for measuring the UAL can best be achieved by lying on the right side of the child.[7]

While body weight is taken in children with CP, the child can be weighed together with the parent, and then the weight of the parent can be removed. In addition, some children may also need a wheelchair, a sitting scale, or a hoist scale. What is important to obtain an accurate weight profile is the consistency of the method.[25]

In the evaluation of the measurements, since the body weight of the patients with CP is below average compared to their peers, CP-specific growth curves should be used.[25] In children with CP, growth patterns deviate significantly from those shown in standard charts by Centers for Disease Control and Prevention, WHO, or others.[29] For this reason, it is much more valuable to monitor the growth in CP with the graphs classified by Gross Motor Function Classification System (GMFCS) level using measurements of weight and height by gender of children with CP.[29]

GMFCS was developed to classify children with SP based on the level of restrictions and functional capabilities. Differences between levels represent differences in gross motor functions which are considered to be important in the daily lives of children with CP. GMFCS aims to improve communication between professionals and families when defining the child's gross motor function, making management decisions, and setting goals.[30] The growth curve is selected according to the classification determined according to GMFCS.

In 2007, Day et al. published weight, height, and BMI reference curves for children with SP between the ages of 2-20, and they classified these curves according to GMFCS and nutritional ability. As a result, they showed that children with less severe CP had growth curves close to the general population.[29] However, in 2011, the growth curves developed by Day in 2007 were revised, and new growth curves were created.[31] All the growth curves created can be accessed at "http://www.lifeexpectancy.org/articles/GrowthCharts.shtml."

The body composition changes in children with CP, and the increase in the extracellular fluid is accompanied by decreased of body cell mass. Relative immobility in children with severe motor impairment leads to a decrease in lean mass.[25]

While BMI is a poor measure of body fat in children with SP, skinfold thickness is an alternative estimation method of body fat, and TSF below the 10th percentile, which is also easy to measure, has been expressed as a strong indicator of low body fat storages and therefore malnutrition in children with CP.[32]

Although various formulations have been developed for the calculation of body fat using skinfold thickness in children with CP, the formulas used quite widely belong to Slaughter et al. (1988).[33] These formulations are shown in Table 2.[33]

TABLE 2: Formulations for body fat % estimation from skinfold thickness.[33]

Total (triceps, subscapular) ≤35 mm	
Female (all)	%Body fat=1.33 (tric+sub)-0.013 (tri+subsc)2-2.5
Male	
Prepubertal black	%body fat=1.21 (tric+sub)-0.008 (tri+subsc)2-3.2
Prepubertal white	%body fat=1.21 (tric+sub)-0.008 (tri+subsc)2-1.7
Pubertal black	%body fat=1.21 (tric+sub)-0.008 (tri+subsc)2 −5.2
Pubertal white	%body fat=1.21 (tric+sub)-0.008 (tri+subsc)2-3.4
Post pubertal black	%body fat=1.21 (tric+sub)-0.008 (tri+subsc)2-6.8
Post pubertal white	%body fat=1.21 (tric+sub)-0.008 (tri+subsc)2-5.5
Total (triceps, subscapular) >35 mm	
Female (all)	%body fat=0.546 (tric+subsc)+9.7
Male (all)	%body fat=0.783 (tric+subsc)+1.6

In a study that looked at the compatibility of Slaughter et al. formulations with body fat obtained using DEXA, it was found that children with CP were estimated to have lower levels of body fat compared to body fat measured by DEXA, and it was stated that the accuracy of the formulation in predicting the amount of fat with a small correction factor.[34]

While underwater measurement is used for the prediction of body density in children with SP, underwater measurement, double-labeled water, and DEXA can be used for body composition.[25] DEXA is a valid method for use in children whose posture has changed.[35] BIA can also be used to measure body composition; however, the suitability of this method in children with CP has not yet been fully established.[36]

SPINAL DEFORMITIES

The disorder of various slopes and alignments of the spine is called spinal deformity. Due to spinal deformities, conditions such as scoliosis, kyphosis, and paraplegia are encountered, which makes it difficult to determine the body weight and height.[37]

Since postural deformities can make it difficult to measure height, stadiometry is the preferred-method to measure the height of children who can stand, while supine length measurement can only be used if the child's extremities are in proper posture.[25]

Actual standing height may be affected by a variety of post-acquired and congenital conditions, including vertebral fractures due to congenital kyphoscoliosis, aging, osteoarthritis, inflammatory arthritis, and osteoporosis.[7] In these cases affecting the actual standing height, standing height is commonly reduced while the arm span is not affected. Therefore, the use of arm span can be a useful measure for predicting height.[7]

Equations were developed by Bassey for the prediction of height from demispan.[38]

- Female: Height (cm)=60.1+[1.35×demispan (cm)]
- Male: Height (cm)=57.8+[1.40×demispan (cm)]

Although the arm span and height are highly correlated, it is difficult to reliably take this measurement in elderly individuals with severe spinal curvature, and therefore, the knee height can also be used for the formula to be applied for height estimation. In such cases where the arm span is difficult to measure, the knee height is preferred over the arm span because knee height is a component of height, and it is more related to height and arm span or other arm length measurements.[10]

Thanks to the formulations obtained as a result of the study conducted by Chumlea et al., body weight and height can be estimated in elderly people with wheelchair-dependent or spinal curvature.[10] While the formulations of Chumlea et al. are suitable for the patients over 65 years of age, there are also formulations suitable for the young population (Table 3).[10]

TABLE 3: Height estimation formulas of Chumlea et al.[10]

Formulas for the elderly population	
Male	
	Height=(2.02 x knee height)-(0.04 x age)+64.19
Female	
	Height=(1.83 x knee height)-(0.24 x age)+84.88
Formulas for the elderly and young population	
Male	
	6-18 years height=40.54+(2.22 x knee height)
	19-60 years height=71.85+(1.88 x knee height)
	>60 years height=59.01+(2.08 x knee height)
Female	
	6-18 years: height=43.21+(2.14 x knee height)
	19-60 years: height=70.25+(1.87 x knee height)-(0.06 x age)
	>60 years: height=75.00+(1.91 x knee height)-(0.17 x age)

An alternative approach to measuring the height of a patient who has no contracture or skeletal disorder but cannot stand up the body's trunk, shoulders, head, and lower extremities are in a straight line and the toe and heel sole are marked on the bed sheet is the distance between these 2 lines is measured using a suitable meter. When this measurement is done carefully, this approach is more correct than estimates from knee height in patients without contractures or skeletal anomalies or.[1]

There are also some difficulties in the determination of body weight in patients with spinal deformities. This may be due to the patient's medical condition, a device attached to the patient (such as life support device), or the absence of wheelchair scales or a suitable bed. If possible, wheelchair or bed scales can also be used to measure body weight.[1]

However, when it is impossible or difficult to take a patient's body weight directly, body weight can be estimated using the equations given in Table 4 using various anthropometric measurements such as MUAC, knee height, subscapular skinfold thickness, and calf circumference.[1,10] Which equation is used depends on the age of the patient and the anthropometric measurements that can be obtained or taken.[1]

There are some errors in estimating body weight when various anthropometric measurements are used, and these errors can be minimized when the equation that requires more variables (4 instead of 2) is used and more attention is paid to measurement technique. Although body weight estimates can be 14 kg more or less than the actual body weight, it is better to make a body weight estimate in the patient. However, these estimated body weight calculations should be used only in patients who cannot be weighed, and every effort should be made to directly measure the body weights of the patients.[1]

Although the BMI value is widely used in the evaluation of nutritional status both in clinic and research, the value of the height in the denominator during the calculation decreases rapidly in the elderly,

TABLE 4: Body weight estimation formulas.[1,10]

Chumlea's body weight prediction formulas (≥65 years)
Female
Body weight=(MUAC x 0.98)+(calf circumference x 1.27)+(subscapular skinfold thickness x 0.40)+(knee height x 0.87)-62.35
Body weight=(MUAC x 0.92)+(calf circumference x 1.50)+(subscapular skinfold thickness x 0.42)-26.19
Body weight=(MUAC x 1.63)+(calf circumference x 1.43)-37.46
Male
Body weight=(MUAC x 1.73)+(calf circumference x 0.98)+(subscapular skinfold thickness x 0.37)+(knee height x 1.16)-81.69
Body weight=(MUAC x 1.92)+(calf circumference x 1.44)+(subscapular skinfold thickness x 0.26)-39.97
Body weight=(MUAC x 2.31)+(calf circumference x 1.50)-50.10
Lee and Nieman's body weight prediction formulas
Female
6-18 years: Body weight=(knee height x 0.77)+(MUAC x 2.47)-50.16
19-59 years: Body weight=(knee height x 1.01)+(MUAC x 2.81)-66.04
60-80 years: Body weight=(knee height x 1.09)+(MUAC x 2.68)-65.51
Male
6-18 years: Body weight=(knee height x 0.68)+(MUAC x 2.64)-50.08
19-59 years: Body weight=(knee height x 1.19)+(MUAC x 3.21)-86.82
60-80 years: Body weight=(knee height x 1.10)+(MUAC x 3.07)-75.81

MUAC: Mid-upper arm circumference.

leading to an incorrect evaluation, especially in the elderly with kyphoscoliosis patients. Alternatively, "demiquet" for old men and "mindex" equation for older women are available to compensate for this incorrect assessment.[7] The use of Mindex and Demiquet is based on Lehmann's study. The formulations used for Mindex and Demiquet equations are given below:[39]

- Mindex=Body weight/demispan
- Demiquet=Body weight/demispan^2

As there is a limitation in the use of BMI to evaluate the nutritional status in the elderly, the evaluation of the results of the 2 alternative indexes mentioned earlier is based on another study, and a series of simple arithmetic equations have been created with the BMI cut off points with WHO suggestions, and as a result, the Asian cut off points for Mindex and Demiquet have been determined.[40] The cut off points are shown in Table 5.[7]

TABLE 5: Mindex and Demiquet classification.[7]

	Mindex (kg/m)	Demiquet (kg/m^2)	BMI (kg/m^2)
Underweight	<55.95	75.60	<18.5
Normal range	55.95-69.25	75.60-93.58	18.5-22.9
Overweight at risk	69.55-75.30	93.98-101.75	23-24.9
Obese I	75.60-90.42	102.16-122.18	25-29.9
Obese II	≥90.72	≥112.59	≥30

BMI: Body mass index.

In the case of paraplegia, body fat mass increases even if the patients do not appear obese or their BMI values are normal, and therefore evaluating with BMI can underestimate the body fat in predicting adiposity. Therefore, BMI is an insensitive marker of obesity in these patients, and estimating adiposity with BMI in chronic paraplegic patients is not sufficient to determine body fat percentage.[41] At the same time, the applicability of the traditional BMI cut-off values is questionable. Clinically applicable new criteria should be established to define obesity for individuals with spinal cord injury (SCI).[42,43] In a study conducted to examine the relationship between adiposity and BMI in men with spinal cord injury, body composition was examined using DEXA, and although there were similar BMI values between the paraplegia group and controls, it was found that there was 9.4% more body fat ($p<0.01$) in the paraplegia group. While the total fat mass was 7.1 kg higher in the SCI group, the lean tissue mass was determined to be 8.9 kg lower.[41]

Waist circumference is also an indicator of visceral abdominal adiposity, and is more related with the cardiovascular disease (CVD) risk than BMI. It was stated that the relationship between CVD and waist circumference is higher in SCI individuals compared to BMI.[42]

In evaluating the body composition, BIA or DEXA was generally used in patients with spinal deformity.[44-48] It is stated that DEXA is a highly reproducible technique in estimating the body composition of wheelchair athletes.[49] However, the BIA method is a relatively simple, fast, non-invasive and easily accessible body composition assessment method compared to other more complex methods such as DEXA or CT.[44] In a study, 13 spinal deformities, 13 healthy control groups were included, and lean mass and body fat mass were determined using DEXA. As a result, total fat mass (31.1±8.2 versus 20.8±6.9) was found to be significantly higher in the SCI group while the lean mass (62.2±8.9 versus 73.5±6.4%) was significantly lower.[47] In another study, lean mass and body fat mass were determined using DEXA in 133 spinal deformities and 100 healthy control (66 tetraplegia, 67 paraplegia) groups. As a result, the total fat mass was higher and the lean mass was lower in the SCI group.[48]

DOWN SYNDROME

Down syndrome (DS), one of the most common chromosomal disorders, is a disease caused by a defect in 21. chromosome and is affected by mental disability, characteristic hand anomalies, facial features, congenital heart defects and many other conditions.[50]

When the growth and development of DS children were examined, it was stated that their birth weights had a lower birth weight and a slower growth rate than non-DS children.[51] In addition, growth retardation and short stature were stated as well-known features of DS.[52] In a study conducted with children aged 3 months to 5 years in India, the growth of children with DS was found to be significantly lower compared to typically developing children. Weight was most affected during infancy, height was more affected as age progressed, and head circumference was similarly affected in all age groups. Moreover, BMI showed a progressive increase with age.[53]

Standard growth curves should not be used in children with DS, as growth and height vary significantly between DS children and healthy children. Because if the growth of a DS child is followed by a standard growth curve, there is a risk of ignoring the development of an additional disease such as hypothyroidism or celiac disease.[54] For this reason, various growth curves specific to DS have been developed.

The growth curves previously published for DS are based on different populations.[52,54-58]

One of the first growth curves for children with DS recognized worldwide is the growth curves developed by Cronk et al. for the children aged 1 month to 18 years old for the American population and is used frequently throughout the world.[52] At the same time, head circumference reference curves were created in DS boys and girls from birth up to 36 months.[59]

However, the growth curves developed for children with DS are not classified according to their levels of disability. However, it has been reported that nutritional status varies according to IQ level in children with mental retardation, and it is stated that it may be more valuable to develop curves for DS according to GMFCS and IQ levels as in SP.[29] Kłosowska et al. has found an association between growth and IQ in children with DS.[60]

Body composition of children with DS also differs from their non-DS peers.[61] While studies have been contradictory, overall, those with DS have a higher percentage of body fat compared to their healthy peers and they have been shown to have higher obesity rates.[62-64] Methods such as magnetic resonance imaging, DEXA, CT, underwater weighing, or BIA are used to evaluate body composition.[65] On the other hand, the high cost and large size of methods such as DEXA, underwater measurement are not suitable for field and clinical use, and not much has been studied in individuals with DS. For these reasons, other methods like anthropometry are also widely used.[62]

In the evaluation of body fat, it is likely to calculate the percentage of body fat using waist circumference or skinfold thickness.[62] However, anthropometry are widely used in situations where economic resources are limited or for the assessment of large populations; however, in this case, the main problem is the selection of the right anthropometric equation.[66] Since it is doubtful whether these equations developed in healthy population are suitable for use in individuals with DS, an equation in which body fat percentage is calculated by using skinfold thickness in individuals with DS [fat percentage (%)=(0.97 x TSF)-(8.869 x gender)+15.6 (TSF (mm), gender: 0 for female, for male 1) was created by González-Agüero et al.[66]

CONCLUSION

Although anthropometric measurement and laboratory methods to be used for the assessment of nutritional status are very important in these groups, especially in individuals with orthopedic (physical) and/or mental disabilities, there are some difficulties. In these individuals, even body weight and height from basic measurements may be difficult to be obtained correctly due to posture disorder, bedridden or other reasons. For this reason, the characteristics of the disabled group should be well known, and the methods to be used for alternative measurements should be decided correctly, and a path should be followed accordingly.

Acknowledgement

The authors thanks to BioRender, the program where the Graphical abstract were created. In addition, the authors would like to thank Gazi University Academic Writing Application and Research Center for proofreading the article.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

***Idea/Concept:** Eda Köksal; **Design:** Merve Esra Çatır Dazıroğlu, Eda Köksal; **Control/Supervision:** Eda Köksal; **Literature Review:** Merve Esra Çatır Dazıroğlu, Eda Köksal; **Writing the Article:** Merve Esra Çatır Dazıroğlu; **Critical Review:** Eda Köksal.*

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