OBESITY RESEARCH

Openventio PUBLISHERS

ISSN 2377-8385 Open Journal http://dx.doi.org/10.17140/OROJ-1-104

Mini Review

*Corresponding author
Masaru Teramoto, PhD, MPH
Assistant Clinical Professor
Department of Health Sciences
College of Nursing and Health Professions
Drexel University
1601 Cherry Street, MS 9503
Philadelphia, PA 19102, USA
Tel. +1-267-359-5718
Fax: +1-267-359-5722
E-mail: Masaru.Teramoto@drexel.edu

Volume 1 : Issue 1
Article Ref. #: 1000OROJ1104

Article History
Received: December 23rd, 2014
Accepted: February 6th, 2015
Published: February 9th, 2015

Citation
Teramoto M, Bungum TJ, Landwer GE, Wagner DR. Association of physical activity to the risk of obesity in adults with physical disabilities. *Obes Res Open J*. 2015; 1(1): 16-23. doi: 10.17140/OROJ-1-104

Association of Physical Activity to the Risk of Obesity in Adults with Physical Disabilities

Masaru Teramoto[1*], Timothy J. Bungum[2], Gerald E. Landwer[3] and Dale R. Wagner[4]

[1]Department of Health Sciences, College of Nursing and Health Professions, Drexel University, 1601 Cherry Street, Philadelphia, PA 19102, USA

[2]Department of Epidemiology and Biostatistics, University of Nevada, Las Vegas, 4505 Maryland Parkway, Box 453064, Las Vegas, NV 89154, USA

[3]Department of Educational Leadership, University of Nevada, Las Vegas, 4505 S. Maryland Parkway Las Vegas, NV 89154, USA

[4]Health, Physical Education and Recreation Department, Utah State University, 7000 Old Main Hill, Logan, UT 84322, USA

ABSTRACT

Adults with physical disabilities have an increased risk of obesity. Physical activity is essential to maintaining healthy weight; meanwhile, it is not fully understood how much physical activity is needed in order to decrease the risk of obesity for this population. This paper discusses the association of physical activity to the risk of obesity in adults with physical disabilities. Body Mass Index (BMI) and percent Body Fat (%BF; measure of body composition) are commonly used for determining the prevalence of obesity. Physical activity can help to achieve and maintain optimal BMI and %BF regardless of the presence of physical disabilities. Meanwhile, the effectiveness of physical activity on reducing the risk of obesity may be different between people with and those without physical disabilities. There are limitations associated with using BMI and %BF for determining the degree of obesity particularly for adults with physical disabilities. More research is needed to examine the association between different physical activity levels and the prevalence of obesity among this population. Future research should also focus on developing general physical activity recommendations for the special populations to help them reduce the risk of obesity and improve the quality of life.

KEYWORDS: Physical activity; Obesity; Physical disabilities; Body Mass Index (BMI); Percent Body Fat (%BF); Body composition.

INTRODUCTION

Obesity is a major health concern in most countries today.[1] Currently in the U.S., more than one-third of adults are reported to be obese.[2] Obesity is associated with a number of chronic diseases, such as coronary heart disease, stroke, type 2 diabetes and certain types of cancer.[3] The annual medical spending attributed to obesity in the U.S. was estimated to be close to $150 billion in 2008, which was nearly doubled since 1998.[4] Therefore, it is essential to raise awareness of the importance of reducing the risk of obesity in the general public.

One of the populations requiring much attention with respect to the risk of obesity is adults with physical disabilities. Physical disability is defined as a significant deviation or loss of body functions and structures, limiting physical activity and participation.[5,6] According to

ISSN 2377-8385 Open Journal http://dx.doi.org/10.17140/OROJ-1-104

the U.S. Census Bureau,[7] approximately 41.5 million adults had some types of physical disabilities in 2010. It was reported that those with physical disabilities used a wheelchair, cane, crutches, or walker; had difficulty in walking, climbing stairs, lifting; and had conditions contributing to an activity limitation, including arthritis or rheumatism, back or spine problem and broken bone or fracture.[7] Research shows that the prevalence of obesity in this population is 1.2- to 3.9- times higher than among those without physical disabilities.[8] Due to limited mobility, total energy expenditure of those with physical disabilities is generally low,[8] increasing the likelihood of the accumulation of excess body fat and the loss of muscle mass and bone mineral content. Consequently, adults with physical disabilities are considered to be at increased risk of obesity-attributable diseases, including type 2 diabetes and coronary heart disease.[9,10]

Physical activity plays a major role in reducing the risk of obesity and diseases associated with obesity.[11] Currently, it is recommended that people should engage in at least 150 minutes per week of moderate-intensity physical activity or 75 minutes per week of vigorous-intensity physical activity to gain substantial health benefits.[12] However, due to limited mobility and functional capacity, adults with physical disabilities cannot engage in physical activity in the same manner as people without disabilities can. According to Healthy People 2010,[13] 56% of people with disabilities report no leisure-time physical activity compared to 36% of people without disabilities. To help those with physical disabilities engage in physical activity, adapted physical activity programs are available, so that people with various disabilities can enjoy and compete together.

Although adults with physical disabilities are also recommended the same amount of physical activity as that of the general population,[12] it is not fully understood how much physical activity is needed in order to decrease the risk of obesity for this population. The current paper discusses how physical activity is associated with the risk of obesity in adults with physical disabilities.

PHYSICAL ACTIVITY ON BODY MASS INDEX

BMI (kg/m^2) classifies individuals into different weight categories and is widely used in epidemiological studies. The World Health Organization[14] defines BMI of less than 18.50 kg/m^2 as underweight, between 18.50 and 24.99 kg/m^2 as normal range, greater than or equal to 25.00 kg/m^2 as overweight and greater than or equal to 30.00 kg/m^2 as obese. It has been shown that higher BMI values are correlated with greater risks of diseases, including type 2 diabetes, hypertension and cardiovascular disease.[15]

Past studies reported that individuals with physical disabilities who were physically active did not meet the BMI criteria for obesity (Table 1). Two studies found that active individuals with Spinal Cord Injury (SCI) or Multiple Sclerosis (MS) were overweight (BMI = 25.3 and 26.0 kg/m^2 respectively).[16,17] Lussier et al.[18] examined two female wheelchair athletes competing nationally and internationally. They reported BMI values of 16.5 and 19.2 kg/m^2 for each athlete, the lowest among the selected studies. In the other studies, BMI values of active individuals with physical disabilities were within the normal range.[19-26]

These findings in the reviewed studies differ from those in the literature indicating that adults with physical disabilities have a higher risk of obesity.[27,28] However, it has been well documented that regular physical activity helps achieve and maintain optimal weight and BMI among the general population.[29] In addition, three studies in table 1 compared BMI between individuals with physical disabilities who were physically active and disabled or able-bodied ones who were sedentary/inactive.[17,23,25] The studies indicated that BMI of those with physical disabilities who engaged in regular physical activity was lower compared to those who were sedentary/inactive regardless of whether they had disabilities or not. In particular, Slawta et al.[17] reported that mean BMI values of individuals with MS who engaged in light- to moderate-intensity and heavy-intensity physical activity were 26.0 and 23.1 kg/m^2 respectively, whereas BMI of those with MS who were inactive was 30.4 kg/m^2. The results of this study may indicate a dose-response relationship between physical activity levels and BMI values among adults with physical disabilities. This dose-response relationship has been observed in the general population.[30,31] Therefore, physical inactivity, not physical disabilities, appears to be a major determinant of BMI and obesity in this population.

It should be noted that there is a limitation associated with using BMI to determine whether or not people are obese. BMI does not account for the composition of body mass. For example, individuals who have a large muscle mass (e.g., strength athletes) may be classified as overweight or obese by BMI when they are actually not in terms of the amount of fat mass. In addition, adults with physical disabilities could undergo drastic changes in fat and fat-free mass components following injury as a result of disuse atrophy.[10,32] In fact, a decrease in muscle/fat-free mass and an increase in fat mass after SCI have been frequently observed.[33,34] Furthermore, recumbent length, often used instead of height when individuals with physical disabilities cannot stand and maintain straight posture, is not likely to provide accurate BMI values. Hence, it is not clear whether the BMI standards used for the general population should also be used for adults with physical disabilities. McDonald et al.[33] suggest that traditional BMI standards would underestimate obesity in people with SCI and thus it would be necessary to develop new BMI criteria for this population. However, BMI is practical, easy to obtain and suitable for large epidemiological studies that are currently lacking and will need to be conducted for special populations. This future research can help develop new BMI standards for special populations, if traditional BMI criteria are not appropriate for them.

ISSN 2377-8385 Open Journal http://dx.doi.org/10.17140/OROJ-1-104

PHYSICAL ACTIVITY ON BODY COMPOSITION

Body composition is commonly expressed as %BF. Excessive body fat indicated by high %BF is associated with diseases, including cardiovascular disease, stroke, hypertension and diabetes.[3,35] There are no universal standards of %BF; however, Gater and Clasey[32] suggest that healthy male and female adults should have %BF of less than 18% and 33%, respectively, while %BF of greater than 22% (males) and 35% (females) are considered obese. Typical techniques to estimate %BF includes: Hydrostatic Weighing (HW), Dual-energy X-ray Absorptiometry (DXA), Skinfold measurements (SKF), whole-body counting of potassium (40K), Total Body Electrical Conductivity (TOBEC) and Bioelectrical Impedance Analysis (BIA).

Past studies that assessed %BF of physically active individuals with physical disabilities are listed in table 1. Slawta et al.[17] found relatively high %BF (30.8-37.6%) among older females with MS (average age of 45-50 years) who engaged in various intensities of physical activity. This observation may have been partly due to the characteristics of the participants in the study, because %BF is generally higher among women than among men and tends to increase with age.[36] On the other hand, two studies reported low %BF (15.6 and 17.4%, respectively) of competitive/elite athletes with SCI or poliomyelitis.[25,37] Ide et al.[26] conducted anthropometric measurements, including %BF, of more than 800 wheelchair marathon racers for 10 years. The study found an average %BF of 18.1-18.4%, even though the gender of the racers is not specified. Compared with BMI, more variability of the data exists in %BF across the studies. In the reviewed studies, the most common methods used to estimate %BF were DXA[9,21-24] and SFK,[17,20,25,26] followed by HW[16,18,19], along with TOBEC[37] and 40K.[18]

Several studies in table 1 compared %BF between the groups with different physical activity levels. The majority of the studies found lower %BF among active individuals with physical disabilities compared to those with or without disabilities

Study	Participants					BMI	Body composition	
	Disability	Activity level	Gender	Age (yr)	N	(kg/m²)	Method	%BF
Bostom et al.[16]	SCI (T5-T12)	Active	Male	30.6	9	25.3[a]	HW	28.7
Bulbulian et al.[19]	SCI (paraplegia)	Moderately trained to competitively conditioned athletes	Male	27.5	22	22.3[a]	HW	22.3
	AB (ectomorphs)	Moderately trained to competitively conditioned athletes	Male	21.1	25	19.4[a]		8.3
	AB (mesomorphs)		Male	22.5	30	26.1[a]		11.3
Dwyer and Davis[20]	Wheelchair bounded	National wheelchair basketball athletes	Female	26.0	13	21.9	SKF	23.3
Ide et al.[26]	Wheelchair bounded	Wheelchair marathon racers(fine racers)	Not specified	33.6	710	20.3[a]	SKF	18.1
		Wheelchair marathon racers(poor racers)		32.4	99	21.0[a]		18.4
Inukai et al.[21]	SCI (high and low paraplegia)	Basketball, track and field and tennis players (practiced3.2 days/week and 9.7 hr/week)	Male	35.6	25	23.2	DXA25.5	

ISSN 2377-8385 Open Journal http://dx.doi.org/10.17140/OROJ-1-104

Jones et al.[9]	SCI (paraplegia and tetraplegia)	Highly active (376 min of physical activity per week)	Male	33.0	20	No data	DXA	27.5
	AB (age-, height- and weight-matched)	Highly active (312 min of physical activity per week)	Male	33.0	20	No data		17.8
Lussier et al.[18]	SCI (T5-L1)	Collegiate elite wheel chairathletes competing nationally and internationally (basketball and other sports)	Female	26.0	2	16.5[a, b] 19.2[a, b]	HW	28.9[b] 32.1[b]
							40K	29.5[b]
								31.1[b]
							SKF[c]	19.1[b, c]
								23.3[b, c]
Miyahara et al.[22]	SCI (paraplegia)	Basketball, track and field and tennis players (practiced 3.6 days/week and 8.7 hr/wk)	Male	34.7	28	22.6	DXA	24.0
	AB	Triathlon athletes, track and field athletes and bicycle racers	Male	33.0	25	21.5		12.8
Mojtahedi et al.[23]	SCI (T5-L5)	Participated in varsity athletic programs (12 hr of sport-specific and3 hr of resistance training per week)	Male and female	22.5	14	22.2	DXA25.1	
	AB (BMI-matched)	Sedentary	Male and Female	22.5	17	24.3		26.5
Olle et al.[37]	SCI (C6-L12)	Exercised 2 days/ week and 120 min/week at high/ competitive intensity	Male	32.4	12	No data	TOBEC	15.6
		No habitual physical activity			5	No data		23.3
Ribeiro et al.[24]	SCI (T5-T12)	Wheelchair basketball players (exercised minimum of 1 hr/day and 3 days/ week)	Male	18-40	28	22.0	DXA	20.6
	Poliomyelitis	Wheelchair basketball players (exercised minimum of 1 hr/day and 3 days/ week)	Male	18-40	32	23.0		25.2
Slawta et al.[17]	Multiple sclerosis	Light-intensity physical activity (comparable to walking pace of 2-3 mph)	Female	50.7	47	26.0	SKF	37.6

		Moderate-intensity physical activity (comparable to walking pace of 3-4 mph)	Female	48.9	40	26.0		37.2
		Heavy-intensity physical activity (comparable to walking pace above 4 mph)	Female	45.8	17	23.1		30.8
		Inactive	Female	53.4	19	30.4		41.3
Zwiren and Bar-Or[25]	Poliomyelitis and	Internationally competed	Male	27.5	11	21.0[a]	SKF	17.4
	paraplegia (T7-L2)	wheelchair athletes(basketball, swimming and javelin)						
	Poliomyelitis and paraplegia (T7-L2)	Sedentary	Male	29.1	9	24.-4[a]		21.9
	AB	Internationally competed athletes (basketball, swimming, discus and wrestling)	Male	26.7	13	24.2[a]		12.5
	AB	Sedentary	Male	31.0		23.5[a]		18.3

Note: BMI = Body Mass Index; %BF = Percent Body Fat; SCI = Spinal Cord Injury; MS = Multiple Sclerosis; AB = Able-Bodied; HW =Hydrostatic Weighing; SKF = Skinfold measurements; DXA = Dual-energy X-ray Absorptiometry; 40K = whole-body counting of potassium; TOBEC =Total Body Electrical Conductivity.

[a]Body mass index calculated from body height and weight.

[b]Data from each participant.

[c]Average of three %BF values from different prediction equations.

Table 1: Studies on Body Mass Index and Body Composition among Adults with Physical Disabilities at Different Physical Activity Levels

who were sedentary/inactive.[17,23,25,37] The results of these studies may indicate that regular physical activity is effective in improving body composition of adults with physical disabilities, as this relationship has been demonstrated in the general population.[29] However, when compared to able-bodied individuals who were active/athletes, %BF of individuals with physical disabilities who were active/athletes was much higher.[9,19,22,25] Specifically, Jones LM et al.[9] found that highly active individuals with SCI had %BF of 27.5% compared to 17.8% among age-, height- and weight-matched able-bodied controls with similar activity levels. Also, two elite female wheelchair athletes had very low BMI values (16.5 and 19.2 kg/m^2 respectively) but their %BF was around 30% estimated by HW or 40K.[18] The findings in these studies indicate that, in spite of engaging in regular physical activity, adults with physical disabilities may have difficulty in increasing or maintaining muscle mass because of the limited ability to contract muscles. This assumption may explain the general trend seen in the reviewed studies that active individuals with physical disabilities had a normal range of BMI but higher %BF. By failing to maintain muscle mass, an individual could lose weight resulting in a lower BMI, but without a concomitant reduction in body fat, %BF would become higher.

Caution must be taken when interpreting the results of the selected studies. All of the studies used a two-component (2-C) model to estimate %BF, though the DXA is sometimes referred to as a three-component (3-C) model.[38] A 2-C model divides the body into two parts, fat and fat-free body, whereas a 3-C model divides the body into three parts (e.g., fat, bone mineral and bone-free lean tissue) and a four-component (4-C) model divides the body into four parts, fat, mineral, water and protein.[38] More assumptions derived from the reference body must be made when using a 2-C model to estimate %BF compared with using multi component models, such as 3-C and 4-C models.[38] Therefore, any deviations in the components of fat-free body (i.e., water, mineral and protein) from the reference

ISSN 2377-8385 Open Journal http://dx.doi.org/10.17140/OROJ-1-104

body would increase the measurement errors.[38] For example, potential changes in the composition of fat-free body following injury among individuals with SCI are well known.[10,32] Hence, there is a greater possibility of underestimating or overestimating %BF of individuals with physical disabilities when a 2-C model is used.

In order to obtain an accurate estimation of %BF among individuals with physical disabilities, a 4-C model is recommended.[32] However, a 4-C model requires more measurements than a 2-C or 3-C model and thus is expensive and time-consuming. If a 4-C model is not feasible, DXA may be superior to 2-C model methods for estimating %BF of paralyzed individuals because the DXA model measures bone mineral content of the body to estimate %BF. It has been shown that bone mineral density is altered in people who are wheelchair-bounded or paralyzed.[39,40] Therefore, DXA could minimize the measurement errors associated with the variations in bone mineral density between the reference body and individuals with physical disabilities. SKF, on the other hand, does not seem to be an appropriate technique for predicting %BF of adults with physical disabilities, including those with SCI.[19,41] However, SKF may be used to assess subcutaneous fat deposits that can be compared within and between individuals. It would be particularly useful to develop practical but valid and reliable techniques for estimating %BF of individuals with physical disabilities. One such example is the work of P.S Kocina[42] who used a multicomponent model and developed a BIA prediction equation to estimate %BF of individuals with SCI.

EFFECTIVE VOLUME OF PHYSICAL ACTIVITY TO REDUCE THE RISK OF OBESITY

The volume of physical activity necessary to prevent obesity among adults with physical disabilities is not clearly defined. However, health experts recommend that 60 min of daily physical activity is needed to prevent weight gain in the general population.[43] Until the guidelines specific to the special populations are developed, it seems prudent that this volume of physical activity recommended for able-bodied individuals be applied to individuals with physical disabilities, as well.

There is the limited number of studies that quantified the volume of physical activity and examined the association between physical activity levels and the prevalence of obesity among adults with physical disabilities (Table 1). Two studies reported that male adults with SCI (mean age = 35.6 and 34.7 years, respectively) whose BMI values were within the normal range (22.6-23.2 kg/m^2) participated in recreational activities at least 3 days per week and spent a total of 8-10 hr per week for the activities.[21,22] Mojtahedi et al.[23] found that young male athletes with SCI (mean age = 22.5 years) engaging in a combined 12 hr of sport-specific activities and 3 hr of resistance training per week had mean BMI of 22.2 kg/m^2 and %BF of 25.1%. Other studies have indicated that an hour of exercise per day for 2-3 days per week could achieve favourable BMI and %BF among people with SCI.[24,37] According to Slawta et al.[17] higher intensity of physical activity seemed to be correlated with lower BMI and %BF among active individuals with MS. In addition, the study suggests that physical activity comparable to walking pace above 4 mph may be necessary to achieve a normal range of BMI among people with Ribeiro et al.[24] found that wheelchair basketball players with poliomyelitis who practiced the minimum of 1 hr/day for 3 days/week had mean BMI of 23.0 kg/m^2 and %BF of 25.2%. Zwiren and Bar-Or[25] reported favourable BMI (21.0 kg/m^2) and %BF (17.4%) values among wheelchair athletes with poliomyelitis or paraplegia who were competing internationally.

CONCLUSIONS AND IMPLICATIONS FOR FUTURE RESEARCH

Physical activity can reduce the risk of obesity and diseases associated with obesity by helping achieve and maintain optimal BMI and body composition. It appears from current literature that adults with physical disabilities can also lower the risk of obesity to some extent by participating in regular physical activity, as well. Individuals with physical disabilities who are physically active tend to have a normal range of BMI and their BMI could be lower than that of sedentary people with or without disabilities. However, caution must be used when interpreting BMI data from this population, because it does not take into account the composition of the body mass; individuals with physical disabilities likely have a reduced muscle mass and an increased fat mass. %BF of active adults with physical disabilities appears to be lower compared to sedentary/inactive counterparts but could be still higher compared to active, able-bodied people. This higher %BF among active adults with physical disabilities could be due to the measurement errors associated with estimating %BF of the special populations or due to the assumption that reported physical activity levels among those with physical disabilities are not sufficient to increase/maintain muscle-mass. Because of the limited number of studies, we were unable to identify the optimal volume of physical activity that can reduce the risk of obesity among adults with physical disabilities. However, even 2-3 hr of physical activity per week may positively affect BMI and body composition for adults with physical disabilities. In addition, there is likely a dose-response relationship such that higher volume of physical activity seems to further reduce the risk of obesity among this population. Until further research is conducted, the physical activity guideline for the general population to prevent obesity (i.e., 60 min/day) may also be recommended to adults with physical disabilities.

Clearly, there is a limited number of existing studies that examine the association between physical activity levels and the prevalence of obesity among adults with physical disabilities. Moreover, recent literature on this topic is certainly scarce and some of the studies reviewed in this paper were published more than 10 years ago. Further studies, especially large epidemiological studies, will be needed to determine how different type/mode, intensity, time and frequency of physical activity affect BMI and %BF in those with physical disabilities. Because of

ISSN 2377-8385 Open Journal http://dx.doi.org/10.17140/OROJ-1-104

the potentially misleading conclusions drawn from BMI in this population, future studies should include the assessment of body composition. To facilitate future studies, it will be necessary to develop accurate and practical techniques for estimating %BF of individuals with physical disabilities. Past studies have focused mainly on people with SCI; therefore, adults with physical disabilities other than SCI will need to be studied in the future, as well. Individuals with physical disabilities are at increased risk for becoming obese, but engaging in regular physical activity and maintaining active lifestyles will likely lessen the prevalence and severity of obesity and obesity-related diseases among them. Therefore, it is imperative to develop general physical activity recommendations for the special populations to help them reduce the risk of obesity and improve the quality of life.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

REFERENCES

1. World Health Organization. Obesity and overweight, 2013. http://www.who.int/mediacentre/factsheets/fs311/en/index.html. Accessed 2014.

2. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity in the United States, 2009-2010. *NCHS Data Brief*. 2012; 82: 1-8.

3. National Task Force on the Prevention and Treatment of Obesity. Overweight, obesity and health risk. *Arch Intern Med*. 2000; 160: 898-904.

4. Finkelstein EA, Trogdon JG, Cohen JW, Dietz W. Annual medical spending attributable to obesity: payer-and service-specific estimates. *Health Aff*. 2009; 28: w822-w831. doi: 10.1377/hlthaff.28.5.w822

5. McCabe MP, Taleporos G. Sexual esteem, sexual satisfaction and sexual behavior among people with physical disability. *Arch Sex Behav*. 2003; 32: 359-369. doi: 10.1023/A:1024047100251

6. World Health Organization. ICF: International classification of functioning and disability. Geneva: World Health Organization. 2001.

7. Brault MW. Americans with disabilities 2010: Household economic studies. U.S. Department of Commerce, Economics and Statistics Administration, US Census Bureau. 2012.

8. Liou TH, Pi-Sunyer FX, Laferrere B. Physical disability and obesity. Nutr Rev. 2005; 63: 321-331.

9. Jones LM, Legge M, Goulding A. Factor analysis of the metabolic syndrome in spinal cord-injured men. Metabolism. 2004; 53: 1372-1377. doi: http://dx.doi.org/10.1016/j.metabol.2004.04.013

10. Kocina P. Body composition of spinal cord injured adults. Sports Med 1997; 23: 48-60.

11. Physical Activity Guidelines Advisory Committee. Physical activity guidelines advisory committee report, 2008. Washington, DC: U.S. Department of Health and Human Services. 2008.

12. US Department of Health and Human Services. 2008 Physical Activity Guidelines for Americans, 2008. http://www.health.gov/paguidelines/pdf/paguide.pdf. Accessed 2014.

13. US Department of Health and Human Services. Healthy people 2010: II. Washington DC: US Department of Health and Human Services; 2000.

14. World Health Organization. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. *World Health Organ Tech Rep Ser*. 2000; 894:1-12, 1-253.

15. Expert Panel on the Identification Evaluation and Treatment of Overweight and Obesity in Adults. Executive summary of the clinical guidelines on the identification, evaluation and treatment of overweight and obesity in adults. *Arch Intern Med*. 1998; 158: 1855-1867.

16. Bostom AG, Toner MM, McArdleWD, Montelione T, Brown CD, Stein RA. Lipid and lipoprotein profiles relate to peak aerobic power in spinal cord injured men. *Med Sci Sports Exerc*. 1991; 23: 409-414.

17. Slawta JN, McCubbinJA, Wilcox AR, Fox SD, Nalle DJ anderson G. Coronary heart disease risk between active and inactive women with multiple sclerosis. *Med Sci Sports Exerc*. 2002; 34: 905-912.

18. Lussier L, Knight J, Bell G, Lohman T, Morris AF. Body composition comparison in two elite female wheelchair athletes. *Paraplegia*. 1983; 21: 16-22. doi: 10.1038/sc.1983.3

19. Bulbulian R, Johnson RE, Gruber JJ, Darabos B. Body composition in paraplegic male athletes. *Med Sci Sports Exerc*. 1987; 19: 195-201.

20. Dwyer GB, Davis RW. The relationship between a twelve minute wheelchair push test and VO_{2peak} in women wheelchair athletes. 1997; 8: 1-11. doi: 10.1080/15438629709512515

21. Inukai Y, Takahashi K, Wang DH, Kira S. Assessment of

total and segmental body composition in spinal cord-injured athletes in Okayama prefecture of Japan. *Acta Med Okayama*. 2006; 60: 99-106.

22. Miyahara K, Wang DH, Mori K, et al. Effect of sports activity on bone mineral density in wheelchair athletes. *J Bone MinerMetab*. 2008; 26: 101-106. doi: 10.1007/s00774-007-0789-1

23. Mojtahedi MC, Valentine RJ, Arngrimsson SA, Wilund KR, Evans EM. The association between regional body composition and metabolic outcomes in athletes with spinal cord injury. *Spinal Cord*. 2008; 46: 192-197. doi: 10.1038/sj.sc.3102076

24. Ribeiro SML, da Silva RC, de Castro IA, Tirapegui J. Assessment of nutritional status of active handicapped individuals. *Nutrition Research*. 2005; 25: 239-249. doi: 10.1016/j.nutres.2004.12.006

25. Zwiren LD, Bar-Or O. Responses to exercise of paraplegics who differ in conditioning level. *Med Sci Sports*. 1975; 7: 94-98.

26. Ide M, Ogata H, Kobayashi M, Tajima F, Hatada K. Anthropometric features of wheelchair marathon race competitors with spinal cord injuries. *Paraplegia*. 1994; 32: 174-179. doi: 10.1038/sc.1994.31

27. Centers for Disease Control and Prevention. State-specific prevalence of obesity among adults with disabilities - Eight states and the District of Columbia, 1998-1999. *MMWR Morb-Mortal Wkly Rep*. 2002; 51: 805-808.

28. Jones GC, Bell K. Adverse health behaviors and chronic conditions in working-age women with disabilities. *Fam Community Health*. 2004; 27: 22-36.

29. Blair SN, Brodney S. Effects of physical inactivity and obesity on morbidity and mortality: current evidence and research issues. *Med Sci Sports Exerc*. 1999; 31: S646-S662.

30. Aadahl M, Kjaer M, Jorgensen T. Associations between overall physical activity level and cardiovascular risk factors in an adult population. *Eur J Epidemiol*. 2007; 22: 369-378. doi: 10.1007/s10654-006-9100-3

31. Bernstein MS, Costanza MC, Morabia A. Association of physical activity intensity levels with overweight and obesity in a population-based sample of adults. *Prev Med*. 2004; 38: 94-104. doi: 10.1016/j.ypmed.2003.09.032

32. Gater DRJ, Clasey JL. Body composition assessment in spinal cord injury clinical trials. 2006; 11: 36-49.

33. McDonald CM, Abresch-Meyer AL, Nelson MD, Widman LM. Body mass index and body composition measures by dual x-ray absorptiometry in patients aged 10 to 21 years with spinal cord injury. *J Spinal Cord Med*. 2007; 30(Suppl 1): S97-S104.

34. Spungen AM, Adkins RH, Stewart CA, et al. Factors influencing body composition in persons with spinal cord injury: a cross-sectional study. *J ApplPhysiol*. 2003; 95: 2398-2407.

35. Pi-Sunyer FX. Health implications of obesity. *Am J ClinNutr*. 1991; 53: 1595S-1603S.

36. Gallagher D, Heymsfield SB, Heo M, Jebb SA, Murgatroyd PR, Sakamoto Y. Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. *Am J ClinNutr*. 2000; 72: 694-701.

37. Olle MM, PivarnikJM, KlishWJ, Morrow JR Jr. Body composition of sedentary and physically active spinal cord injured individuals estimated from total body electrical conductivity. *Arch Phys Med Rehabil*. 1993; 74: 706-710.

38. Heyward VH, Wagner DR. Applied body composition assessment. 2nd ed. Champaign, IL: Human Kinetics. 2004.

39. Takamoto S, Masuyama T, Nakajima M, et al. Alterations of bone mineral density of the femurs in hemiplegia. *Calcif Tissue Int*. 1995; 56: 259-262.

40. Kiratli BJ, Smith AE, Nauenberg T, Kallfelz CF, Perkash I. Bone mineral and geometric changes through the femur with immobilization due to spinal cord injury. *J Rehabil Res Dev*. 2000; 37: 225-233.

41. Maggioni M, Bertoli S, Margonato V, Merati G, Veicsteinas A, Testolin G. Body composition assessment in spinal cord injury subjects. *Acta Diabetol*. 2003; 40(Suppl 1): S183-S186. doi: 10.1007/s00592-003-0061-7

42. Kocina PS. Clinical assessment of body composition in the spinal cord injured population. *The University of New Mexico*. 1997.

43. Brooks GA, Butte NF, Rand WM, Flatt JP, Caballero B. Chronicle of the Institute of Medicine physical activity recommendation: how a physical activity recommendation came to be among dietary recommendations. *Am J Clin Nutr*. 2004; 79: 921S-930S.