Comparison of basal metabolic rate in individuals with a spinal cord injury and Harris-Benedict equation: a systematic review

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ABSTRACT

Tables for calculating the energy expenditure of the physical activities of the general population cannot be used due to the different paralysis of the upper or lower limbs in people with spinal cord injury (SCI). The purpose of this review is to compare the differences in the values of basal metabolic rate (BMR), basal energy expenditure (BEE), resting energy expenditure (REE) and resting metabolic rate (RMR) the values evidenced in the literature, observed values vs predicted values using the Harris-Benedict equation. We realized the background research from the time period from 1985 to 2018. We searched in PubMed, Web of Science and Scopus databases for articles addressing the relationship between BMR and people with SCI. We compared the parameters of BMR, BEE, REE and RMR according to Harris-Benedict (HB) equation for persons with SCI. The study confirmed that the energy expenditure of persons with SCI could not be evaluated correctly by the Harris-Benedict equation.

KEYWORDS

indirect calorimetry; lean tissue; predicted values

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INTRODUCTION

BMR measurement in humans attracted considerable interest during the early part of the 20th century. They were primarily used for the diagnosis of hypo- and hyperthyroidism. BMR tests marked a new era in clinical medicine (Henry, 2005). The first record of this method to estimate the energy expenditure was described in 1985 Food and Agriculture Organization/World Health Organization/United Nations University Joint (FAO/WHO/UNI). The FAO nutrition studies No. 1513 published in 1957, entitled Calorie Requirements, represented a landmark both in approach and analysis. These simple linear equations to predict total energy requirements bear close resemblance to the linear equation used to predict BMR today (Food and Agriculture Organization of the United Nations,1957). It is usually expressed as heat production or oxygen consumption per unit of body size. BMR is the daily rate of energy metabolism an individual needs to sustain in order to preserve the integrity of vital functions. It must be measured under conditions, which, as far as possible, avoid the influence of the external environment (Henry, 2005). Persons with chronic SCI have been reported to have a reduction in metabolic rate (Mollinger, Nyulasi, Collier, & Brown, 1985; Spungen, Bauman, Wang, & Pierson, 1993). Lean tissue is the most metabolically active body tissue, and muscle mass, a predominant component of lean tissue, appears to be lost over time in those with SCI at a rate exceeding that of the able-bodied population (Spungen, Wang, Pierson, & Bauman, 2000; Spungen et al., 2003).

MATERIALS AND METHODS

The methods for the article selection and inclusion criteria were based on the procedures for systematic reviews producer by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses according to the PRISMA guidelines (Moher et al., 2015). Ethical approval for this study was obtained from the Faculty of Physical Education and Sport at the Charles University Prague (No. 172/2014).

Eligibility Criteria

We evaluated controlled, cross-sectional studies on the BMR, BEE, REE and RMR of people with SCI. Studies were considered eligible if they addressed voluntary strategies aimed at measurement of basal metabolic rate (BMR), basal energy expenditure (BEE), resting energy expenditure (REE), resting metabolic rate (RMR), spinal cord injury (SCI) and paraplegia. The primary outcomes of interest were values energy expenditure measurement by indirect calorimetry. It was restricted to studies on human subjects. English language review, that examined energy expenditure of SCI persons with injury between the vertebrae segments from C4 to S5. SCI was defined as someone with a mobility impairment reliant on wheelchair motion. The search included report about with SCI aged comparison of Basal Metabolic Rate in individuals with a spinal cord injury and Harris-Benedict equation 4–72 years old, time of injury 7 days to 25 years with complete and incomplete SCI. If not otherwise stated, all the studies reviewed fulfil the following criteria: exclusion of patients with tracheostomy, active infections, thyroid dysfunction, heterotopic ossification, respiratory dysfunction, diabetes, Crohn's disease, renal disease, heart disease, cauda equine syndrome, amputation, and non-traumatic spinal cord injury.

Descriptors were select using the MeSH (Medical Subject Headings) database. The following expressions were used: basal metabolic rate (BMR), basal energy expenditure (BEE), resting energy expenditure (REE), resting metabolic rate (RMR), spinal cord injury (SCI), tetraplegia, paraplegia.

The search strategies used in electronic bibliographic databases including PubMed, the Scopus database (Table 1), Web of Science and the Central Library of our University. Records published between January 1985 and January 2018.

Table 1 Search strategies used PubMed and Scopus database

Scopus (n = 20)	PubMed (n = 12)
ALL (basal AND metabolism) AND TITLE-ABS- KEY (energy AND expenditure) AND TITLE-ABS- KEY (resting AND metabolism) AND TITLE-ABS- KEY (spinal AND cord AND injury) AND TITLE-ABS-KEY (tetraplegia) AND TITLE-ABS-KEY (paraplegia)	("energy metabolism"[MeSH Terms] OR ("energy"[All Fields] AND "metabolism"[All Fields]) OR "energy metabolism"[All Fields] OR ("energy"[All Fields] AND "expenditure"[All Fields]) OR "energy expenditure"[All Fields]) AND ("rest"[MeSH Terms] OR "rest"[All Fields] OR "resting"[AllFields])AND("metabolism"[Subheading]OR"metabolism"[All Fields] OR "metabolism"[MeSH Terms] OR "metabolism"[All Fields] OR "metabolic networks and pathways"[MeSH Terms] OR ("metabolic"[All Fields] AND "networks"[All Fields] AND "pathways"[All Fields]) OR "metabolic networks and pathways"[All Fields]) AND ("spinal cord injuries"[MeSH Terms] OR ("spinal"[All Fields] AND "cord"[All Fields] AND "injuries"[All Fields]) OR "spinal cord injuries"[All Fields] OR ("spinal"[All Fields] AND "cord"[All Fields] AND "injury"[All Fields]) OR "spinal cord injury"[All Fields]) AND ("quadriplegia"[MeSH Terms] OR "quadriplegia"[All Fields] OR "tetraplegia"[All Fields]) AND ("paraplegia"[MeSH Terms] OR "paraplegia"[All Fields])

Data extraction

We aimed to evaluate and compare out all studies that measured parameters BMR, BEE, REE, RMR in persons with SCI against the results of Harris-Benedict equations. Anthropometric data were substituted into the equation from the average values. The Harris-Benedict equations BMR:

for men = 88.362 + (13.397 × mass in kg) + (4.799 × height in cm) – (5.677 × age in years)

for women = 447.593 + (9.247 × mass in kg) + (3.098 × height in cm) – (4.330 × age in years) (Harris & Benedict, 1918).

RESULTS

Basal metabolic rate

BMR is the amount of energy needed to sustain the involuntary activities of the body at rest after a 12-hour fast. Most of these involuntary activities are regulated by the autonomic nervous system and include maintaining muscle tone, body temperature, and proper functioning of the heart, lungs, and gastrointestinal tract (Yilmaz et al., 2007). The main difference between BMR and RMR lies in the resting and fasting time before measurements.

Many variables such as age, height, body mass, ethnicity, and body surface area, body composition, diet-induced thermogenesis and recent physical activity may influence the prediction of RMR (Buchholz, Rafii, & Pencharz, 2001). BEE by our definition, was the energy expended by an individual when initially waking in the morning while lying supine in bed at normal body and ambient temperatures after at least a 12 hour fast. REE was defined as the energy expended by an individual when seated at least 4 hour post-prandial at normal body and ambient temperatures (Bauman, Spungen, Wang, & Pierson, 2004).

Method measurement by indirect calorimetry

Principle of indirect calorimetry is the usual method of measuring energy expenditure. Measurement of the amount of heat (energy) produced by a subject by determination of the amount of oxygen consumed and the quantity of carbon dioxide eliminated (Fujii & Phillips, 2002). It is easier to carry out than direct calorimetry and provides information about the metabolic fuel that the body is using (Mann & Truswell, 2002).

These studies used the indirect calorimetry method for BMR, BEE, REE and RMR measurement with different medical device and body position (sitting or lying).

According to Herring, Molé, Meredith, & Stern, (1992) the underlying principle for indirect calorimetry is that oxygen is needed for the production of energy and carbon dioxide is release as an end-product metabolism. Thus, the rates of oxygen (VO_2) consumed and carbon dioxide (VCO_2) production is measured in breath samples. Samples can be measured in a respiration chamber or by an open circuit ventilated hood system, which is the most common. For this assessment, breath samples are collected from a subject lying in supine position in a comfortable environment for about 30–40 minutes. At least 12 hours of fasting is required so that there is no energy required for digestion and absorption of ingested food. Athletes also should avoid exercise for 48 hours prior to the measurement to eliminate the effects of acute activity because exercise can increase RMR up to 39 hours post-exercise.

All studies are made with the persons called in resting state. Studies definition resting state as:

- The subject be fasted for at last 4 to 14 hour before the measurements are taken.
- The subject be minimum of 24 hours post-exercise.
- The subject as well as to abstain from caffeine or alcohol intake, no smoke the last 24 hours.
- The environment in which the measurements are taken be thermo-neutral (22–26°C) so that there is no thermoregulatory effect on heat production.
- he subject be completely rested, both before and during the measurements. It could be lying or seated and fully awake.

Medical device indirect calorimetry

The metabolic cart

The metabolic cart essentially measures the oxygen consumed and the carbon dioxide produced by the patient and then calculates (using the modified Weir equation) the energy expenditure for the patient (Fujii & Phillips, 2002).

Med Gem
Hand-held calorimeters such as the MedGem™ and BodyGem™ (Microlife, 2019) have been developed to measure energy expenditure (Hipskind, Glass, Charlton, Nowak, & Dasarathy, 2011). While traditional indirect calorimeters measure both VO_2 and VCO_2, the hand-held devices measure only VO_2 where RQ is assumed to be 0.85 (Microlife, 2019).

Douglas bag
This is a large bag impermeable to gas, usually of volume 100 liters. The subject wears a nose clip and breathes out into the bag via a tube containing a valve which separates inspired from expired air (Mann & Truswell, 2002).

Respiration chambers
The subject's respiratory gas exchanges are measured by continuous analysis of well-mixed samples of air from the chamber. From differences in oxygen and CO_2 content between the air going in and the air coming out the respiratory exchange is calculated and from this the energy expenditure of the subject (Mann & Truswell, 2002).

Predicting equations for people with SCI
According to Harris & Benedict (1918), Mifflin et al. (1990), Nightingale & Gorgey (2018) in clinical practice, BMR is often predicted using equations which feature variables that are easily measured: body weight, stature, and/or age. However, a recent review reported that such equations, derived from able-bodied populations, over predicted BMR by 4–92% in persons with SCI.

To date, no studies in persons with SCI have sought to assess the improvement in the prediction of BMR with the addition of simple anthropometric measurements that can be easily obtained. In non-disabled individuals, the addition of fat free mass (FFM) to a regression equation using the predictors of mass, height, and age increased the associations between predicted and criterion BMR from $r^2 = 0.71$ (SEE = 125 kcal/d) to $r^2 = 0.80$ (SEE = 103 kcal/d) (SEE – Standard Error of the Estimate). In the study thirty men with chronic (>1 year) motor complete and the results of this current study demonstrate that the addition of anthropometric measurements to FFM (Table 2, model 3) explains an additional 8% of the variance in BMR. For researchers/clinicians without access to expensive scanning equipment (DXA), a final prediction algorithm was generated (Table 2, model 4), with the FFM predictor variable removed. This explained the least variance in criterion BMR ($r^2 = 0.57$) (Table 2). SEE was also calculated to determine the accuracy of these prediction models. The accuracy of commonly used BMR prediction equation remains to be assessed in a cohort only representative of men with chronic (> 1 year) SCI.

In the predicted equations there were not observed significant differences in BMR between paraplegic (1497 ± 148 kcal/d) and tetraplegic (1467 ± 178 kcal/d) participants. According to Nightingale & Gorgey (2018) previous studies have demonstrated increased BMR in paraplegic compared with tetraplegic participants of (370 and 224 kcal/d), whereas other researchers have shown there to be no difference.

Table 2 Generated BMR prediction models using FFM and anthropometric measurements

Model Name	BMR (kcal/d) Prediction Algorithm	R^2	SEE (kcal/d)
1. FFM alone	= 23.469 × FFM (kg) + 294.330	0.69	93
2. FFM plus circumferences and diameters	= 23.995 × FFM (kg) + 6.189 × SAD (cm) + 6.384 × TAD (cm) – 6.948 × THIGH CIRC (cm) + 275.211	0.73	90
3. FFM plus anthropometrics	= 19.789 × FFM (kg) + 5.156 × weight + 8.090 × height – 15.301 × calf (cm) – 860.546	0.77	84
4. Anthropometrics alone	= 13.202 × height (cm) + 11.329 × weight (kg) – 16.729 × TAD (cm) – 1185.445	0.57	112

Note: SAD – sagittal abdominal diameter; TAD – transverse abdominal diameter; THIGH CIRC – thigh circumference; SEE – Standard Error of the Estimate; FFM – fat free mass; BMR – basal metabolic rate.

DISCUSSION

The parameter BMR for normal population is commonly evaluated by Harris-Benedict equation. For persons with spinal cord injury this method is not taking into consideration the muscle atrophy under the spinal lesion. According to Nash & Gater (2007) the authors recommend estimation of baseline energy expenditure using indirect calorimetry to avoid inaccurate applications of non-validated energy prediction equations. Similarly, activity tables previously determined for energy expenditure in non-SCI adults markedly overestimate the caloric expenditure required for persons with SCI. In the early phase rehabilitation that patients with SCI require up to 54% fewer calories than would be predicted by standard formulae (Cox et al., 1985).

In this review there are results of people time of injury 7 days to 25 years with and in the age 33.78 ± 16.73 years. One of the factors which influenced the parameter BMR for person with SCI is FFM. Deitrick, Whedon, & Shorr (1948) reported an average 7% reduction in BMR for healthy subjects whose lower extremities were immobilized in plaster casts, indicating that immobilization of a large muscle mass alone can lower BMR. Evidently, part of the reduction in BMR found in patients with spinal cord injury was due to the imposed immobility of their paralyzed limbs.

According to Gorgey et al. (2010) body composition may vary widely among individuals with SCI as a result of the level of injury, years after injury, and extent of physical activity. The dramatic muscle atrophy in patients with acute SCI is clearly related to the degree of paralysis and immobilization (Bauman et al., 2004; Kalani, Brismar, Fagrell, Ostergren, & Jorneskog, 1999). Persons with SCI have body compositional changes that are similar to those reported in the elderly, with loss of lean tissue and relatively increased adiposity (Alexander, Spungen, Liu, Losad, & Bauman, 1995; Evans, 1995) although the anthropometrical distribution of muscle mass may differ (Bauman et al., 2004). Strong correlations between altered body composition and the level of SCI have been observed, with successively higher, more complete spinal cord lesions associated with decreased FFM and body cell mass (Nuhlicek et al., 1988).

Tetraplegia is associated with significantly lower rates of BEE than paraplegia (Munakata et al., 1997; Cameron, Nyulasi, Collier, & Brown, 1996; Mollinger, Nyulasi, Collier, & Brown, 1985; Spungen, Bauman, Wang, & Pierson, 1993) largely due to greater muscle denervation found in those with cervical lesions (Buchholz, McGillivray, & Pencharz, 2003b). According to Spungen, Wang, Pierson, & Bauman (2000) and Spungen et al. (2003) the lean tissue is the most metabolically active body tissue, and muscle mass, a predominant component of lean tissue, appears to be lost over time in those with SCI at a rate exceeding that of the able-bodied population.

In comparison with nondisabled controls, BMR is significantly reduced by 14–27% in persons with SCI, although values were comparable between groups when adjusted for FFM (Buchholz, et al., 2003b). Reductions in BMR after SCI are primarily driven by skeletal muscle disuse atrophy below the level of the injury (Spungen, Wang, Pierson, & Bauman, 2000).

A major disadvantage of equations that use body weight to predict BMR is that this variable is unable to distinguish between FFM and fat mass (FM). FFM has been shown to explain most of the variance in BMR, with other studies demonstrating an independent, secondary contribution of FM (Nightingale & Gorgey, 2018).

To date, the progress towards developing a validated predictive energy equation targeted for SCI has been slow and unsuccessful, and indirect calorimetry remains the only accurate assessment of REE for health practitioners working with individuals after SCI (Nevin, Steenson, Vivanti, & Hickman, 2016).

Spungen et al. (1993) reported the relationship between measures of lean body tissue and energy expenditure. In our sample group total body potassium (TBK) was reduced by about one third. Because approximately 98% of the TBK is located in lean tissue (viscera and skeletal tissues), TBK is a surrogate for the FFM, and a change in FFM should be associated with a concomitant change in REE. Mollinger et al. (1985) reported that in 16 subjects with high paraplegia (T1 through T10) and in 5 subjects with low paraplegia (below T10), percentages of predicted basal metabolic rates were reduced, at 12% and 15%, respectively. The resting energy expenditure is reduced in proportion to the loss of lean body tissue, which is determined by the degree of muscle atrophy below the level of lesion.

Table 3 compares the differences between the parameter BMR (overestimate 25% and underestimate 35%), BEE (overestimate 18% and underestimate 0%), REE (overestimate 26% and underestimate 2%) and RMR (overestimate 36% and underestimate 4%) for persons with SCI. Selected studies used the different medical devices (Table 3), Metabolic cart and Hand-held calorimeters MedGem, BodyGem are used as indirect calorimetry medical devices. According to Hipskind et al. (2011) results from a hand-held calorimeter were similar to those obtained from metabolic cart studies. The hand-held device was compared to metabolic carts in 9 studies with mixed results. The predictive equations (Harris-Benedict, Mifflin St. Jeor and FAO/WHO equations) were found to over-and/or underestimate RMR compared to the MedGem. The Harris-Benedict equation was found to overestimate the RMR by 3–11%.

Table 3 Comparison of BMR, RMR, BEE and REE values from the literature: observed values vs. predicted values using the Harris-Benedict equations

	First author (year)	Subjects	Age range (y)	Male	Female	Total	Methods, position	Medical device	% difference
1	Mollinger et al. (1985)	C4–6	19–48	14		48	BMR/L	Metabolic Cart	+21
		C6–Th1	19–48	13			BMR		−26
		Th10–S4	19–48	16			BMR		−47
		Th4–L1	19–48	5			BMR		−52
2	Sedlock & Laventure (1990)	Th4–L1	29–31	4		4	RMR/L	Metabolic Cart	+16
3	Kearns et al. (1992)	Mixed Race				10		Douglas Bag	
		C4–Th10	16–72	7			REE/L		+10 (males)
		C4–Th10	16–72		3				−2 (females)
		C4–Th10	16–72	7			BEE/L		No difference
		C4–Th10	16–72		3				−12 (females)
4	Spungen et al. (1993)	Th1–S4	39–46	12		12	REE/S	Metabolic Cart	No difference
5	Alexander et al. (1995)	NPS, Th1–S4	47–53	24		24	RMR/S	Metabolic Cart	−14
		PS, Th1–S4	47–53	14		14	RMR/S		+1
6	Alexander et al. (1995)	NPS, Th1–S4	47–54	24		24	BMR/S	Metabolic Cart	+1
		PS, Th1–S4	47–54	14		14	BMR/S		+1
7	Monroe et al. (1998)	C6–L3	22–49	10		10	RMR/L	Respi-ration Chamber	−4
8	Jeon et al. (2003)	C5–7	35–45	7		7	RMR/L	Metabolic Cart	+23
9	Buchholz et al. (2003a)	Mixed Race				27		Metabolic Cart	
		Th1–S4	22–57	17			RMR/L		+6 (males)
		Th1–S4	24–41		10				+6 (females)
10	Bauman et al. (2004)	Mixed Race				13		Metabolic Cart	
		C5–L2	25–47	9			BEE/L		+18 (males)
		Th7–L1	21–49		4				+6 (females)
		C5–L2	25–47	9			REE/S		−2 (males)
		Th7–L1	21–49		4				−14 (females)

11	Liusuwan et al. (2004)	Mixed Race				27		Metabolic Cart	
		C4–S5	10–21	18			RMR/L		+12 (males)
		C4–S5	10–21		9				+7 (females)
12	Patt et al. (2007)	Mixed Race				59		MedGem	
		C4–L3	4–20	31			REE/S		+15 (males)
		C4–L3	8–21		28				+10 (females)
13	Yilmaz et al. (2007)	Mixed Race				20		Metabolic Cart	
		C4–S5	16–50	13			BMR/L		+18 (males)
		C4–S5	17–50		7				−2 (females)
14	Gorgey et al. (2010)	Spastic, Mixed Race				10		Metabolic Cart	
		C6–Th11	18–45	8			RMR/L		+27 (males)
		C6–Th11	18–45		2				+17 (females)
15	Perret & Stoffel-Kurt (2011)	Mixed Race				12		MedGem	
		C5–Th12	22–46	9			REE/L		+21 (males)
		C5–Th12	22–46		3				+12 (females)
16	Tanhoffer et al. (2012)	Mixed Race				14		Metabolic Cart	
		C4–Th12	23–65	13			BMR/L		+19 (males)
		C4–Th12	23–65		1				+7 (females)
17	Buchholz et al. (2003b)	Mixed Race				28		Metabolic Cart	
		S4–S5	20–57	17			RMR/L		+6 (males)
		S4–S5	20–57		11				−4 (females)
18	Nightingale & Gorgey (2018)	C5–L1	19–61	30		30	BMR	CosMed	+42 (males)

Note: Position: L – lying; S – seated; Spastic group – ASIA classification A, B; PS – pressure sores, NPS – no pressure sores.

LIMITATION

According to Patt, Agena, Vogel, Foley, & Anderson (2007) many facilities and practitioners do not have access to full metabolic cart analysis. Measuring an accurate height may be challenging in those with SCI due to their scoliosis and lower extremity contractures (Liusuwan, Widman, Abresch, & McDonald, 2004).

According to Adams & Hicks (2005) is spasticity due to an upper motor neuron disorder that affects 70% of patients with chronic cervical and thoracic level injuries

1 year after injury. Spasticity is a complex phenomenon of exaggerated muscle tone, reflexes, and clonus that affects the skeletal muscles below the level of injury. Despite its negative influence, spasticity could be viewed as expressing positive features. For example, spasticity has been shown to improve ambulation and peripheral circulation.

According to Alexander et al. (1995) the patients with paraplegia and pressure sores were found to have significantly greater resting energy expenditure per kilogram of body weight and percent predicted energy expenditure than those with paraplegia without pressure sores. Pressure sores may also be expected to increase the resting metabolic rate. It has been reported that patients with complete lesions have the highest incidence and most severe pressure sores.

Spasticity related alterations might occur at basal energy requirements. On the other hand, another factor that may help spasticity to alter BMR it is contribution to lean tissue mass. Periodic recruitment of large skeletal muscle mass could result in high energy expenditure and defend against increase in FM after SCI (Gorgey et al., 2010). In accordance with recent findings (Yilmaz et al., 2007) spasticity was not directly related to the RMR. However, successfully maintaining FFM resulted in increased RMR, respiratory exchange ratio, and substrate utilization, as documented by increased fat oxidation. Knee extensor spasticity positively decreases the ratio between FM to FFM in legs, trunk, and whole body. The increase in FM relative to FFM can be simply attenuated by provoking spasticity in both lower extremities (Gorgey et al., 2010).

There are results of energy expenditure in the Table 3. The persons with the pressure sores had 1% higher results, the spastic male patients had 27% higher and spastic female patients 17% higher results vs. Harris-Benedict equation ones.

Gorgey et al. (2010) had found that spasticity improves glucose homeostasis, insulin sensitivity, and lipid profile by primarily maintaining FFM. Additionally, maintenance of FFM has been shown to positively influence the RMR and hence the basal metabolic profile. According to Stjernberg, Blumberg, & Wallin (1986) Sympathetic nervous system (SNS) activity has been shown to be lower in persons with spinal cord injury than in control subjects. The individuals with lower SNS activity may be at greater risk for weight gain because of a lower metabolic rate (Monroe et al., 1998). According to Yilmaz et al. (2007) the relationship between energy expenditure and autonomic nervous system is controversial. Positive correlations were reported between daily energy expenditure and sympathetic activity. However, some studies showed that β-adrenergic blockade did not affect daily energy expenditure. On the other hand, the influence of sympathetic nervous system on BMR was reported to be relatively small. After SCI, autonomic nervous system dysfunction is a common complication mostly seen in patients with T6 or upper level injuries. However, the effect of this autonomic nervous system dysfunction on BMR in persons with SCI remains unclear.

Anti-spasticity medications commonly prescribed in SCI have been shown to suppress REE in non-injured populations and common secondary complications such as pressure injuries and urinary tract infections may increase energy needs (Nevin et al., 2016).

According to Silverstein (1992) cigarette smoking may have a hindering effect on pressure ulcer healing due to vasoconstriction and reduced blood flow to the skin, resulting in tissue ischemia.

Cigarette smoking has been found to increase energy expenditure in the general population. It is of interest to note that more individuals who had pressure sores were current smokers than in either the NPS (no pressure sores) – Para or control groups (Alexander et al., 1995).

As it is demonstrated in the table 3 the methodology of the studies is not completely uniform. Studies in this review used the different position of body during and Medical device of the measurement. Compher et al. (2006) states that certain postures require increased muscle tone and may influence the measurement of RMR. In 24 adults with a weight range of 48 to 109 kg, group mean RMR measured while sitting upright motionless was 70 kcal/d higher than supine RMR (3.7–6.3% increase). A recent review reported that predicted values by SCI for resting energy expenditure overestimate actual values by between 5% and 32% (Buchholz & Pencharz, 2004).

CONCLUSIONS

There are many factors that affect the whole value of the BMR in people with SCI. The indirect calorimetry method looks like the most accurate one among the available methods determining BMR in people with SCI. Our study has confirmed that the predictive Harris-Benedict equation cannot be used for the calculation of BMR in people with SCI. Indirect calorimetry can be an essential method that dietetics professionals can use to build a reduction diet in people with SCI. It is also very important to have respect for the limitations of this particular group of people. According to Nevin et al. (2016) investigating the feasibility of introducing indirect calorimetry into standard care of SCI and pursuing lower cost alternatives to current equipment needs is warranted.

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