RUSSIAN JOURNAL OF
SPORTS SCIENCE
2023, Vol. 2 (3)

Publication date: 01.09.2023
DOI: 10.24412/2782-6570-2023_02_03_2
UDC 577.121

DOES METABOLISM DECLINE WITH AGE?

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Annotation. Low resting energy expenditure is considered a risk factor for weight gain leading to obesity. Many studies have shown that aging is associated with a decrease in basal metabolism. We examined the association between age and changes in basal metabolism in men and women, and the causes of this change. Linking these causes at the subcellular/cellular level to organs and tissues and then to body size and shape provides a comprehensive understanding of individual changes in basal metabolism in old age, which is a current topic of interest in obesity research and clinical practice.
Keywords: age, basal metabolism, obesity, body composition, thyroid, fat-free mass, body mass index.

Introduction. Many studies show that in adulthood people, who live in different countries, have lowered total energy expenditure. It is due to the lowered resting energy expenditure (REE), physical activity and, possibly, decreased thermogenesis [1]. Pontzer et al [2] revealed that total expenditure increases depending on the fat-free mass (FFM), even at various life stages. Expenditure that was corrected into FFM increases rapidly in newborn and exceed indices of an adult man by ~50% at the age of ~1 year, then gradually reduces to the adult level at the age of ~20 years, remains stable at the adult age (20-60 years) even during pregnancy, then reduces among the elderly. However, an obesity pandemic among older population [3] should have led to the increased REE due to increased number of energy tissues. Taking analysis of the problem field, data of the modern scientific literature and requests from sports physicians, physiologists and dietitians into account, we have made a study's objective.

The objective: to examine factors influencing basal metabolism reduction in the elderly.

Methods and organization. The study took place in the Russian University of Sport "GTSOLIFK" (Moscow). For the review, we searched and analyzed scientific publications. Following databases were used: PubMed, Embase, Research Gate and Cochrane Library.

Results and discussion. *Organ and tissue level.* In 1907, the English scientist Joseph Barcroft started reporting on a series of studies about catheterization aimed towards evaluation of the specific metabolic rate (*Ki*) of main organs and tissues [4]. In 1950, Drabkin and Jean [5] noted about assessment of basal oxygen consumption by the brain, heart, liver, kidneys and skeletal muscles, and by 1992, the gathered data led to the point that Elia [6] suggested *Ki* values for most main organs and tissues. Merge of these calculated values with corresponding masses of organs and tissues contributed to a measure, with the help of which one could calculate REE as a sum of REE of the main organs and tissues (table). According to this approach, REE of an organ/tissue is the product of their calculated *Ki* value and mass [7]. Despite the great progress achieved in the last century, the ability to measure REE at this level still remains limited [1]. Firstly, there is a dire need in methods allowing a quantitative assessment of *Ki* values in vivo in most organs and tissues (as a result modern physiological models include assessed *Ki* values for some main organs/tissues, but they are not recognized for such components as the digestive tract and lungs. Instead, the tissues, for which there is no *Ki* value, are frequently united into a big "residual" component, which then takes the assessed *Ki* value, although it adds a mistake in the REE evaluation).

Table

Mass specific metabolic rates (*Ki* values) of separate organs and tissues

Organ	Mass, kg		*Ki*, kcal/kg/day	Energy expenditure, kcal/day	
	Male	Female		Male	Female
Brain	1.6	1.43	240	384	343
Kidneys	0.3	0.27	440	132	119
Heart	0.33	0.28	440	145	123
Liver	1.68	1.5	200	336	300
Skeletal muscles	30.6	21.3	13	398	277
Fat tissue	19.3	29.6	4.5	87	133

A second limitation is that volumes of whole organs assessed through magnetic resonance imaging (MRI) cannot consider non-metabolic active components such as blood, connective tissue and fat, which can be contained in different amounts in the skeletal muscles, liver and other organs. This difference can affect the organ's density, as well as the value that is now considered as constant when transforming volumes measured with MRI into mass. Thirdly, the published *Ki* values may inaccurately point out regional differences in oxygen consumption, which occur in some organs/tissues, such as the brain [9]. The same thing is possibly attributed to the fat tissue, a very diverse tissue located in different parts of the whole body.

Level of the whole body. Body mass (BM) is a sum of all heat-emitting components at the level of cells and organs/tissues and a relatively small amount of a metabolically stable substance, such as hair, tendon and extracellular connective tissues. Connection between REE and body mass is a definitive sign of mammals, including man, which was formed by the Kleiber law, REE=BM*0.75 [10]. Therefore, BM is a main REE variable and predictor at the whole body level and is a key component of modern prediction equations [11]. Human body consists of 78 organs and 11 systems, which have relatively stable proportions among adults with normal BM. It is one of the reasons why men and women with reference features have the same corresponding REE values [12] and *Ki* for the whole body (i.e. REE/BM) – 24.3 and 23.6 kcal/kg/day, and why REE strongly correlates with BM in adults [7]. Essentially, all adult people are built the same, which is why BM accounts for more than two-thirds of individual differences in REE.

Excess BM and obesity are serious diseases, the incidence of which among old Europeans amounts to 60% and 20% accordingly [13] and in 50% in general around the world [14]. Obesity is characterized with excessive fat accumulation, which usually occurs during aging [15]. It mostly happens in people aged 45-70, the peak BM is registered in middle age, i.e. 50-65 years [16]. Most studies concluded that REE is significantly higher in obese people (by 360 kcal/day), average values of REE amounted from 90 kcal/day (I degree obesity compared to people without it) to 826 kcal/day (morbid obesity compared to people without it) [17]. The reason for it is that obesity is described not only with an excess of fat and muscle mass, but also with increased mass of other "accompanying" organs (liver, kidneys, heart) and tissues (skin) and related metabolic processes [18]. These data are difficult to correlate with the results found by Pontzer et al [2], since they found that total energy expenditure remains stable in adult age (20-60 years) then reduces in old age. There are two possible explanations for this. First of all, old people might have much lower REE for 1 unit of cell mass for separate organs/tissues (specific metabolic rate) than young people. Cells of organs/tissues may be different in young and old people, since histological changes, which show relative loss of these cells and expansion of extracellular compartments (e.g. connective tissue), occur in the liver and other tissues [19-20]. It is possible that adaptive changes in women take place in middle age (~47 years), while in men – in ~54 years [21].

However, working out stabilize gene expression and protein content in complexes of the electron transport chain [22], which demonstrates full preservation of active muscle cells, which can support relatively high REE in old age. Secondly, it is also well-known that relatively high REE correlated with higher levels of thyroid hormones [23], which gives a possibility to assume that reduced thyroid activity would reduce REE as well in old age.

Thyroid in old age. Main factors defining a need in energy include REE, physical processes, BM and diet frequency [24]. REE, being an important parameter of energy need, is significantly connected with thyroid hormones. Many studies revealed that the level of thyroid hormones increases in old age (>80 years) [25-28]. In terms of connection between obesity, age and thyroid hormones, a current study made by Masoumi and Pishva [29] shows that the thyroid hormone level (T3, T4 and thyroid stimulating hormone) remained within the norm in all obese people (women aged 30-50). Work by Ozcelik et al [30] demonstrated that at late stages of obesity, the increased level of thyroid hormones contributes to a raise of energy consumption by increasing resting energy need and giving the body an alternative option to “save” itself from obesity. Such case is an adaptive and preventive contribution similar to the leptin effect that correlates with an amount of fat tissue in case of obesity, inhibits diet, making an effect on the satiation center.

Conclusion. Obesity is considered as a risk factor of metabolic and chronic diseases. Reduced REE in old age may increase the risk of obesity. Analysis and accumulation of literature on this topic reflects a number of patterns. The first one implies an old person with normal BM, who leads a sedentary lifestyle. In this case REE will possibly decrease as result of losing cell fracture of organs with high *Ki*. Second pattern includes an old person with obesity, who leads a sedentary lifestyle. In this case REE will possibly increase as a result of increased mass of muscles, fat and organs with high *Ki*, as well as the increased thyroid hormone level. The third one implies an old person with normal BM, who leads an active lifestyle. In this case, a stable or increased REE is possible as a result of preserved or increased mass of skeletal muscles accordingly. This is the reason why enlightenment for the elderly on physical culture and sports is necessary, since physical activity contributes to preservation of metabolically active muscle cells that may support a relatively high REE in old age. Additional randomized research in this field is necessary.

Conflict of interest. The authors declare no conflicts of interest.

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For citation: Miroshnikov A.B., Rybakova P.D. Does metabolism decline with age? *Russian Journal of Sports Science: Medicine, Physiology, Training*, 2023, vol. 2, no. 3. DOI: 10.24412/2782-6570-2023_02_03_2