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EFFECT OF SHOE MASS AND FLEXIBILITY VERSUS ENERGY EXPENDITURE OF WALKING

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The matter of shoe ergonomics is rigidly connected with the effect of shoe mass and flexibility. These variabilities cause influence the value of energy cost of locomotion process. It has been shown, that the relationship between mass and elasticity of shoes is translated into the level of human exertion. This fact may lead to changes in mechanical and metabolic data i.e. contact time, stride duration, stride frequency, ground reaction patterns (specifically the maximum magnitudes of vertical, anterior posterior and medial lateral components), total work, oxygen consumption or net efficiency. In performed studies the influence of shoe mass and elasticity has been confirmed.

From the ergonomic point of view, the energy expenditure is often used as a rate of human physical effort during variety of everyday activities i.e.: working, relaxation, walking, sitting, sleeping other more advanced actions. Calorimetry method [1-2], which is known for a long time [5], gives a lot of information, which are necessary to evaluate the energy expenditure during daily activities. For us the most important are these actions, where feet are engaged, like walking or diversity of kinds in area of active recreation. It has been shown [3], that the possibility of predicting the minimal energy cost of human activities, like walking exists. McArdle [4] shows that under the steady – state conditions, the respiratory quotient (VCO_2/VO_2 – the ratio of carbon dioxide production relative to oxygen consumption) provides an useful index for determining energetic equivalent per liter of consumed O_2 (Table 1).

Table 1 – Estimated energy equivalent (EE) versus respiratory quotient (RQ) [3].

RQ	*EE (kcal/l O_2)*
0.71	4.690
0.75	4.739
0.80	4.801
0.85	4.862
0.90	4.924
0.95	4.985
1.0	5.057

Footwear is not crucial factor, which gives an impact on the full energy expenditure. Although the comprehensive expertise in the field of physiological and mechanical determinants of locomotion process is necessary in accurate choice of shoe materials. So it suggests, that this phenomena is important in understanding several aspects of human gait – from energetic costs to possible injuries. Investigations, which have been done in Footwear Department of Institute of Leather Industry in Lodz, shows (Table 2), that for shoes with different flexibility, the value of maximal oxygen consumption (VO_{2max}) was increased from – 1,4 % to 2% (for the most flexible shoes). Analogous effect was observed in shoes with different quantifications of shoe comfort (in view of shoe construction, materials and individual preferences of subjects). The lower oxygen consumption (average 0,7%) for the most comfortable shoes was observed. Moreover the correlation between mass and energetic cost of running was exhibited – oxygen consumption was decreased by 1% per each 100 g of growth in shoe mass.

Table 2 – Types of shoes, their material characteristics and energy expenditure. (*stiffness measurement of shoes procedure according to PN EN-ISO 20344:2012)

Type of shoes	Upper shoe material	Sole shoe material	Mass (g)	Class of elasticity*	Gross energy expenditure (Kcal/min)
A	napa leather	porous rubber	220	I	4,227
B	bovine leather	butt	850	IV	5,703
C	bovine leather	rubber	910	III	5,032
D	yearling leather	rubber	620	II	4,601
E	bovine leather	rubber	880	III	5,020

Walking and other ways of active recreations require the muscle activation, which depends on some factors, like: bodyweight, composition, limb morphology, mass and flexibility of shoes [6, 7]. Heavy and viscous shoes cause higher muscle loading, than lightweight and elastic ones. In extreme conditions the probability of injuries and deformations in osteoarticular system increases. So the ideal footwear should be possibly lightweight and flexible, to minimize the impact of negative shoe material conditions.

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