Location of body centre of mass of Polish high jumpers

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1. Introduction

Assessment of sport performance is based on mechanical analysis of a movement. In high jump there are two main sequences: a run-up and a jump. The efficiency of a high jump can be described taking into account location of a centre of mass of a jumper while acquiring a standing up-right position and then at the highest position over a bar during a jump. The difference of those locations is taken into account in calculating efficiency of high jump index [5] – see Fig. 1. Since the configuration of a trunk acquired over a bar is usually bent (Fig. 2), so detailed, individual data are needed while locating a centre of mass of the trunk (here, Erdmann’s procedure was used where trunk was divided onto five segments – fig. 3 [3]) and then of the whole body. The aim of this paper was to obtain location of body centre of mass for up-right position of sportsmen specializing in athletics’ high jump in order to use this data for calculating efficiency of high jump index.

2. Methods

2.1 Material

Investigations were performed on 11 Polish high jumpers (17-26 years of age, mean = 21.5 years). Six of them had sport international champion and champion class. Others had sport I or II class. During 2004 – 2005 years they were the best jumpers in Poland in their age categories. Their height was 188 – 196 cm (mean = 190.5 cm), mass 65 – 84 kg (mean = 76.0 kg). Personal best results were 197 – 236 cm (mean = 219.5 cm), and their number of years of training were 3 – 9 years (mean = 6.3 years).

2.2 Methods of research

During investigations procedures for obtaining geometric and inertial data (mass, location of centres of mass) of a trunk Erdmann’s method was used [3, 4] and data of a head and extremities were obtained using Chandler et al. [1] and Clauser et al. [2] equations. Geometric data were gathered with photogrammetry and anthropometry methods. Photographs were obtained in two planes – frontal and sagittal. For the purpose of calculating trunk data this part of a body was divided onto three portions and later on eleven sub-portions. The borders of sub-portions were: A – cervicale, B – suprasternale, C – bifurcatio tracheae, D – xiphoidale, E – thoraco-lumbalis (Th12/L1), F – zonale laterale, G – omphalion (umbilicus), H – lumborum-sacralis (L5/S1), I – iliospinale, J – symphysion, K – perineale (see Fig. 4). Sub-portions were presented as geometrical figures, namely non-circular right frusta. This enabled calculation of their volume. Tissues were divided on non-changeable (bones, visceral, circulation) and changeable (muscle, fat, skin). Measurements of skin-fat integument allowed calculation of skin-fat volume. By subtracting from the whole volume of a trunk non-changeable tissues and skin-fat integument, volume of muscle tissue was obtained.

Using density data obtained for trunk tissues by Erdmann and Gos [6] and individual volume of tissues, individual mass of tissues was obtained. Data on proportions of tissues divided onto consecutive trunk’s segments [3] allowed calculation of mass of trunk’s segments for individual subjects. Data on mass of other segments were obtained using regression equations given by Chandler et al. [1] and Clauser et al [2] – Fig. 5.
Taking into account Erdmann’s data [3] locations of centres of mass for trunk’s segments were obtained. For calculating location of centres of mass of head, neck and extremities’ segments regression equations of Chandler et al. [1] and Clauser et al [2] were used.

Fig. 4 Photographs of a subject in frontal (A) and sagittal (B) planes and with divisions along anthropometric landmarks in order to obtain portions and sub-portions.

Fig. 5 Mass of segments obtained from Chandler et al. [1], Clauser et al. [2] and Erdmann [3] data for average non-training people, published in [3].

he – head; ne – neck; th – thorax; ab – abdomen; pe – pelvis; sh – shoulder; ar – arm; fo – forearm; ha – hand; ul – upper leg; ll – lower leg; fo – foot

3. Results

Fig. 6 presents data on mass of segments of high jumpers. These data differ especially for lower extremities comparing to non-training subjects. Fig 7 presents location of entire body’s centre of mass using data for non-training subjects and for high jumpers. Location of the latter centre of mass was lower due to relative higher mass of lower extremities.

Fig. 6 Calculated mass of segments based on high jumpers’ data [7].

Fig. 7 Location of centre of mass of the entire body of the same high jumper with sum of mass (graphical) method using data for: A – non-training subjects, B – for high jumpers [7].

4. References