SEGMENT INERTIAL PROPERTIES OF JAPANESE AND KENYAN ELITE MALE DISTANCE RUNNERS DETERMINED BY THREE-DIMENSIONAL BODY SCANNER

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INTRODUCTION

Elite distance runners have a specific morphology characterized by less fat, thin extremities and light body mass. This means that their segment inertial properties differ from those of other athletes or the average person. Therefore, we have to use an appropriate set of body segment inertia parameters (BSP) when we analyze the motions of elite distance runners with higher accuracy. Furthermore, Larsen (2003) suggested that one of the reasons for the dominance of Kenyan distance runners was the morphology of their shank [1]. However, segment inertial properties for Kenyan distance runners have not been reported yet.

The purposes of this study were to determine the mass, the location of the center of mass, and the moment of inertia about three principal axes of the body segments for Japanese and Kenyan elite male distance runners and to examine whether their segment inertial properties significantly affect the dominance of Kenyan distance runners or not.

METHODS

Subjects were 14 Japanese (22.1 ± 0.9 yr.) and 6 Kenyan (20.3 ± 2.8 yr.) elite male distance runners. Ten of the 14 Japanese subjects had a personal best record below 28 min 30 sec for 10,000m ($28'10" \pm 18"$). Three others had a personal best record below 13 min 40 sec for 5,000m and another had a personal best record below 8 min 35 sec for 3,000mSC. Kenyan subjects, including the fifth place runner for 10,000m in the IAAF world championships, had better average personal best record for 10,000m ($27'49" \pm 33"$).

Using an optical body scanner (Bodyline Scanner C8300, Hamamatsu Photonics K.K., Japan) with four laser diodes and CCDs, three-dimensional position coordinates of point group on the body surface of subjects were measured in their standing position at 2.5mm intervals of height. These coordinates were imported into 3D-CAD software (SolidWorks 2008, SolidWorks Japan K.K., Japan) and a solid model for the body was made from the configuration formed by the point group. The solid model was divided into the following 14 or 15 segments after Ae et al. (1992) [2]: Head, whole torso (which was furthermore divided into upper torso and lower torso), upper arms, forearms, hands, thighs, shanks and feet (see Fig. 1). For each segment, the volume, center of volume, and preliminary moment of inertia with the density of 1g/cm^3 were calculated by the modeling kernel. Segment density was assumed to be uniform and optimized with subject's total body mass based on 26 sets of cadaver segment densities of Dempster (1955) and Chandler et al. (1975) [3,4]. From the volume, the preliminary moment of inertia, and the optimal density, the mass, the center of mass, and the moment of inertia were determined for each segment.
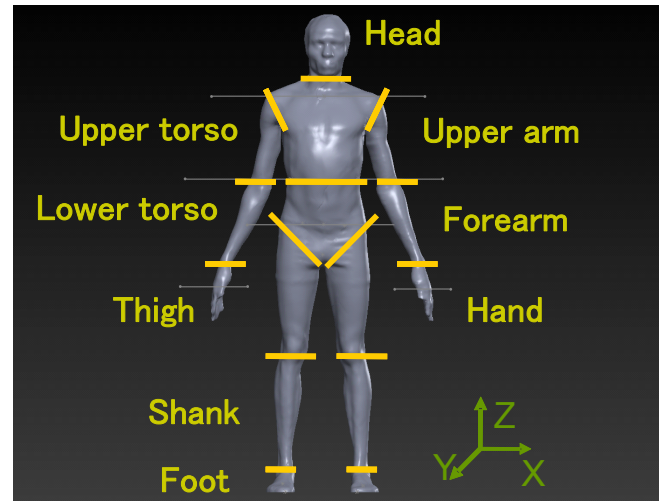

Figure 1 Solid model for each segment and coordinate system

RESULTS AND DISCUSSION

The mean errors in the estimated total body mass were $0.04 \pm 0.44\%$ (maximal error: -0.88%) for Japanese runners and $0.02 \pm 0.37\%$ (maximal error: -0.49%) for Kenyan runners.

There were significant differences in many body segment inertia parameters between Japanese and Kenyan runners. The masses of the upper arm, forearm and hand for Kenyan runners were significantly greater than those for Japanese runners, while their head mass was significantly less. The moments of inertia about the medio-lateral axis of the upper arm, forearm, hand, thigh, shank and foot for Kenyan runners were significantly greater than those for Japanese runners, while their moment of inertia about the medio-lateral axis of the head was significantly less. Kenyan runners were characterized by having longer and heavier segments of upper and lower extremities and larger moment of inertia of these segments.

CONCLUSIONS

Kenyan runners had longer and heavier segments of upper and lower extremities than Japanese runners. This suggested that the dominance of Kenyan distance runners was not attributed to the segment inertial properties themselves, since they had greater segment inertia in their upper and lower extremities.

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