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HUMAN BODY SEGMENT PARAMETERS DETERMINED BY 3D SCANNING ANTHROPOMETRY

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SUMMARY
Purposes of the present study were to develop 3D anthropometry by optical triangle method using laser beam system and to determine feasibility of body segment parameter measurements such as lengths, circumferences, masses and moment of inertia with comparing to previous studies.
Bodyline scanner (BLS) was capable of digitizing whole body shape as three dimensional coordinates in the order of 2.5mm intervals. Subjects were Japanese sixty seven males and females aged from 9 to21yrs. Each segment length and circumference were measured based on anatomical landmark points. For each subject, identical segment length and circumference data were taken by tape measuring conventional manual methods. Scanning whole body data were dissected into each segment as the same manner as Clauser CE, et al. After segmental length, circumference and volume were calculated, segment masses were determined by multiplying segmental volume to respective segmental density obtained from previous study [1]. Relative segment mass to body weight in each segment was very similar to previous studies except for the segments of trunk and thigh. Previous relative segment mass values have a tendencies for overestimation in trunk, whereas underestimation in thigh. This should take into account for calculating mechanical parameters in biomechanical research.

INTRODUCTION
Body segment parameters such as segment masses, lengths, center-of-mass locations and moments of inertia have been determined by a number of different methods. In previous studies, they have been derived from cadavers [1, 2], from direct measument [3], from regression equations, and from mathematical modelling [4]. Recently, another approach to estimating body segment parameters involves scanning the living body with various techniques such as gamma mass scanning, photogrammetry, MRI and DEXA. Whole Body Measurement System for humans “Bodyline Scanner" which has functions such as a high speed measurement and high resolutions are required by many industrial and academic areas such as apparel and digital technology.
Purposes of the present study were to develop 3D anthropometry by optical triangle method using laser beam system and to determine feasibility of body segment parameter measurements such as lengths, circumferences, body surface and body/segment masses with comparing to previous studies.

METHODS
Bodyline scanner (BLS) was capable of digitizing whole body shape as three dimensional coordinates in the order of 2.5mm intervals in space as shown in Fig.1 (normal adult body shape put in ~500,000 points). The principle of the measuring method was optical triangle measurement, in which light source was using a laser diode. The color information was used to detect the position of land mark seals which was pasted on the skin according to the anatomical basis in human anthropometry. Subjects were Japanese sixty seven males and females aged from 9 to

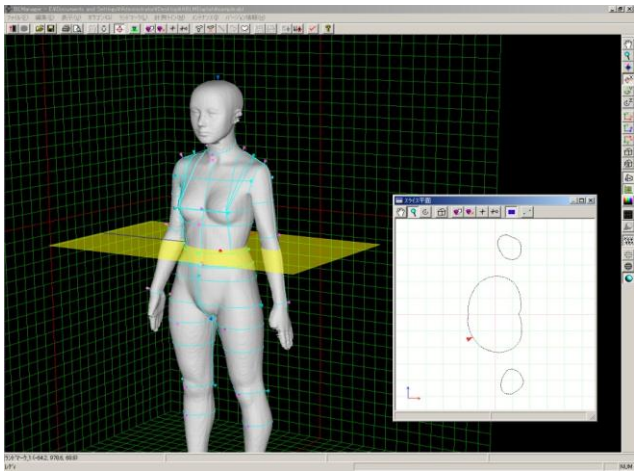

Figure 1: Laser beam sheet scanning during human standing posture for determining 3D anthropometric data.

21yrs (males: 23.8yrs, 171.5cnBH, 68.7kgBW, female: 27.4yrs, 156.7cmBH, 54.4kgBW in averages). Each segment length and circumference were measured based on anatomical landmark points. For each subject, identical segment length and circumference data were taken by tape measuring conventional manual methods. Scanning whole body data were dissected into each segment as the same manner as Clauser CE, et al. [1]. After segmental length, circumference and volume were calculated, segment masses were determined by multiplying segmental volume to respective segmental density obtained from previous study [1].

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RESULTS AND DISCUSSION

Differences of lengths and circumferences of the limbs between BLS and TAPE were within 4%. Relative segment mass to body weight in each segment was very similar to previous studies except for the segments of trunk and thigh (Table 1). Previous relative segment mass values have a tendencies for overestimation in trunk, whereas underestimation in thigh. This should take into account for calculating mechanical parameters in biomechanical research. Differences of lengths and circumferences of the limbs between BLS and TAPE were within 4%. Moments of inertia for three axis in each segment were identical with previously reported values.

CONCLUSIONS

Validity and accuracy of laser beam scanning anthropometry might be established with comparison of conventional tape measure with overall % differences of 1.7 in length measures and 2.8 in circumference measures. In relative segmental mass to body weight, lower trunk value and higher thigh value were indicated by comparing to previous studies in cadavers. Body segment parameters estimated from 3D body scanner are prospective for both biomechanical and biomedical fields.

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Table 1: Relative segment mass to body weight (unit: %) for each segment and comparison to previous studies.

	Present 2012	Dempster 1955	Clauser 1969	Cheng 2000
# of subj.	12	8	13	8
Methods	BLS	Cadavers	Cadavers	MRI
Head	7.3	8.1	7.3	7.7
Trunk	45	49.7	50.7	46.2
U-arm	2.7	2.8	2.6	4
F-arm	1.7	2.2	1.6	1.5
Hand	0.6	0.6	0.7	0.7
Thigh	12.9	9.9	10.3	13.6
Calf	4.8	4.6	4.3	4.4
Foot	1.1	1.4	1.5	2