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RELATIONSHIP OF ANTHROPOMETRIC MEASUREMENTS TAKEN ON CLOTHING TO THOSE TAKEN ON BODY

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ABSTRACT

Anthropometric measurements are of fundamental importance in school health care. Sometimes it is not practical to take the measurements on body and so the measurements are taken on clothing. This paper introduces relations to convert girths (circumferences) taken on clothing to those taken on body.

Introduction

Anthropometric measurements play an important role in biomechanical and motor performance research. They are used in the study of human size, shape, proportion, composition and maturation to help understand human growth and nutritional status (Prahl-Andersen, Kowalski and Heydendael, 1979; Waaler, 1983). These studies are important in the fields of medicine, education and government.

For the growing school child, the value of anthropometric measurements taken at regular intervals to monitor any growth or nutritional abnormality is well established. Therefore, anthropometric measurements are an essential part of school health examinations. However, the lack of accurate and scientifically acceptable assessment has made it very difficult for the clinician to document exactly the various anthropometric measurements (Kamal and El-Sayyad, 1980).

Statement of the Problem

Many of the anthropometric measurements used are grossly inaccurate. The main obstacles for the general acceptance of more detailed anthropometric studies are a lack of generally accepted selections of measurements, a lack of adequate statistical material for the evaluation of such measurements, the use of crude equipment, and the complicated character of many of the suggested examinations with and without clothes (Kamal and El-Sayyad, 1980).

Anthropometric methods acceptable for use in school health practice have to be simple, should not require too much time and, if possible should not require special equipment. Sometimes it is not practical to take the measurements on body and so the measuremens are taken on clothing (Ramachandran, Deshpande, Apte and Shukla, 1968).

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There is a need to obtain reliable mathematical relations that relate anthropometric measurements taken on clothing to those taken on body.

Mathematical Relations

If B and D are the breadth and the depth respectively, of the portion of the body being measured, taken on clothing of thickness a, and b and d are the breadth and the depth respectively without clothing, they are related by

$$b = B - 2a \tag{1}$$
$$d = D - 2a \tag{2}$$

Thickness of the clothing can be measured by a micrometer screw gauge.

Consider the measurement of girth (circumference). Girth is the perimeter of the curve of the horizontal cross section of the portion (e.g. chest, waist, arm, thigh etc.) being measured. Let me choose the origin inside the cross section and introduce polar coordinates r, θ. The curve of cross section is a function of r and θ and let $r = r(\theta)$ i.e. r, the distance from the origin to any point on the curve is a function of the angle made by the radius vector and a fixed line. $r\ d\theta$ is the arc length of the curve between $r(\theta)$ and $r(\theta + d\theta)$. Therefore the perimeter is

$$g = \int_0^{2\pi} r\ d\theta \tag{3}$$

which is the girth (of chest, waist etc.). If the thickness of the tight fitting clothing worn is a, the new radius vector (which is also a function of the angle θ) will be related to the original radius vector by

$$R = r + a \tag{4}$$

This is a reasonably good approximation (see appendix). The observed girth is

$$G = \int_0^{2\pi} R\ d\theta = \int_0^{2\pi} (r + a)\ d\theta \tag{5}$$

Using Eq. (3) I get

$$g = G - 2\pi a \tag{6}$$

and so the girth without clothing can be calulated if a is known.

For the loose fitting clothing Eq. (6) has to be modified. Consider Fig. 1. Let a be the thickness of the loose fitting clothing. The loose part of the clothing may be taken,

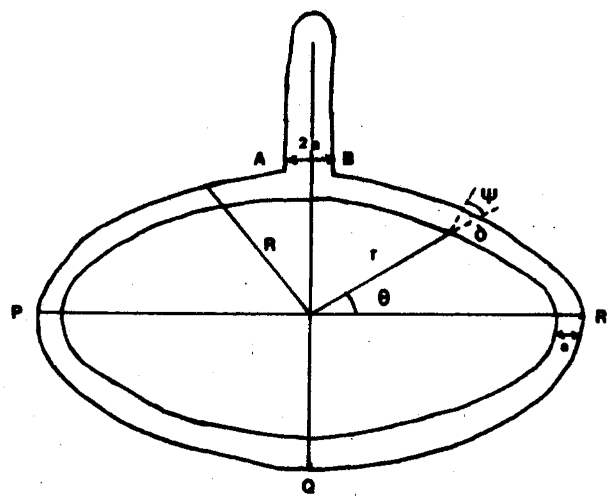

Fig. 1: Measurement of girth on loose fitting clothing.

to fix things, in the form of two layers as shown in Fig. 1. The remaining part is now the tight fitting clothing.

The mentioned two layers should be held close together. The thickness of the two layers is now 2a. The length of the outer contour is given by

$$G = APQRB + BA \tag{7}$$

where BA is the distance between B and A. Note from the figure that BA = 2a and if APQRB = G′, I have

$$G = G' + 2a \tag{8}$$

Using Eq. (6) I get

$$g + 2\pi a = G' + 2a \tag{9}$$

which gives

$$g = G' + 2a(1 - \pi) \tag{10}$$

From the measuring tape G′ can be measured between the points A and B on the clothing and 2a can be measured using the micrometer screw gauge for the two layers of clothing taken on the front side.

Eqs. (1), (2), (6) and (10) can be rearranged in the form

$$(g/2a) = (G/2a) - \pi \tag{11}$$
$$(b/2a) = (B/2a) - 1 \tag{12}$$
$$(d/2a) = (D/2a) - 1 \tag{13}$$
$$(g/2a) = (G'/2a) - (\pi-1) \tag{14}$$

Eq. (11) shows that a graph between (g/2a) and (G/2a) is a straight line with slope unity. Similar straight lines will be obtained for Eqs. (12–14).

Conclusion

The relations presented here may be used in field studies where the examinees could change into standard clothing of known thickness. They also offer some idea of error introduced by clothing, which is not more than 1% in most cases. Anthropometric measurements should not be taken on clothing for studies involving growth disorders.

Eqs. (12) and (13) have already been checked in a field study (Kamal and El-Sayyad, 1980). It is hoped that these mathematical relations and more accurate anthropometric measurements (Kamal, 1982) will enable the medical personnel to deduce specific physiotherapeutic treatment from the analysis of the anthropometric measurements.

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[μ] Full text: http://www.ngds-ku.org/Papers/C19.pdf

[ν] Full text: http://www.ngds-ku.org/Papers/C09.pdf

Appendix

Let ψ be the angle between r and the normal to the girth (circumference) curve. Eq. (4) includes the approximation of δ = a sec ψ by a. This approximation depends on the assumption that ψ is small.

Consider Fig. 1. The perimeter of girth is an ellipse with b (breadth) and d (depth) as major and minor axes respectively. The equations of the ellipse can be written as

$$x = b \cos \theta, \qquad y = d \sin \theta \tag{1}$$

The slope of normal at the point (r,θ) is given by

$$m = -[(dy/dx)_{(r,\theta)}]^{-1} = (b/d) \tan \theta \tag{2}$$

Since the slope of r is tan θ, tan ψ can be written as

$$\tan \psi = [(b/d) \tan \theta - \tan \theta] / [1 + (b/d) \tan^2 \theta] \tag{3}$$

which gives

$$\sec \psi = \sec \theta \, (d^2 + b^2 \tan^2 \theta)^{1/2} \, (d + b \tan^2 \theta)^{-1}; (0^\circ < \theta < 90^\circ)$$

Taking b = 12.83 cm, d = 11.83 cm[£] [Table 1 of Kamal and El-Sayyad (1980)], I get sec ψ = 1.0000, 1.0007, 1.0000 for $\theta = 0^\circ, 45^\circ, 90^\circ$ respectively. Therefore sec $\psi \simeq 1$ is a good approximation.

[£] These are the average values of breadth and depth of chest for a sample of 16 children (10 boys and 6 girls) between the ages of 2 and 7 years.