THE SUM OF SKINFOLDS AND THE O-SCALE SYSTEM FOR PHYSIQUE ASSESSMENT RATING OF ADIPOSITY

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Abstract: *The use of a sum of skinfolds to represent adiposity in the O-Scale physique assessment systems (Ross and Ward 1984, Ward et al. 1989) is based on the rationale that the thicker folds are accorded proportionally greater weighting than the smaller folds. This is why the sum of six skinfolds from different regions of the body is preferred to one or two measures or upper body sites only. Another advantage in using the sum of six sites is that the technical error of measurement is markedly reduced and as we demonstrate, the sum approximates theoretical expectancy in combining errors where the error at each site is assumed or known to be uncorrelated with that of other sites.*

Key words: *Adiposity; Error; Skinfolds; O-Scale System.*

Garn et al. (1987) recognizes that the sum of skinfolds provides an expression of relative adiposity and that the thicker folds are accorded disproportional weighting compared to smaller sites. This is precisely why the sum of six skinfolds was used in the *O-Scale System* (Ross and Ward 1985, Ward et al.1988) which provides adiposity ratings of males and females age 6 to 70 years old. In the design of the system, it was accepted that the adiposity rating should reflect upper limbs, torso and lower limbs. This is in marked contrast to methods which used only upper body sites. In 6 male and 7 female unembalmed cadaver dissections, the front thigh was the best predictor of dissectible adipose tissue mass in the males and the second best in females and best single site over all, and the medial calf the best discriminator in the females (Martin 1984).

The main advantage of the sum of six skinfolds is that is represents a regional sampling of the body and it is highly precise compared to measurement at any single site as illustrated in *Table 1* using the following formulae:

$$\text{TEM} = [(\text{sum } X_1 - X_2)^2 / 2n)]^{0.5}$$

$$\%\text{TEM} = 100 \, (\text{TEM} / M_1)$$

where: TEM   = the technical error of measurement
X_1 and X_2 = replicated scores in separate series
M_1 = mean of the first scores

This was illustrated using replicated measures on 50 adult males and females using Slim Guide calipers and the techniques specified by Ross and Marfell Jones (1990). In terms of the technical error of measurement, the sum of the six values used in the O-Scale System appeared to approximate the general formula (Beers 1957) when one assumes the error in each set is independent, rewritten as follows:

$$E = (e^2_1 + e^2_2 + \ldots + e^2_n)^{0.5}$$

As shown in *Table 1*, the obtained TEM and %TEM for the sum of six skinfolds was more stable than any of the single items. While we can rationalize values of the TEM for the sum higher in the females than theoretically projected (1.52 compared to 1.35 mm) by assuming some small covariance factor, we have no explanation for the lower values for the males (0.93 compared to 1.01 mm). Because individual profiles are sensitive to error as well as change, it is our practice to use the median of three measures from an initial and twice replicated series. This further enhances precision of measurement.

Table 1. **Technical error measurement for eight skinfold sites, the sum of six sites, and theoretical expectancy**
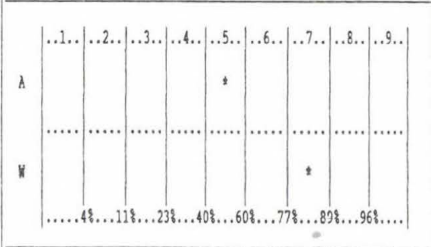
Skinfold Site	Men (n = 50)		Women (n = 50)	
	TEM mm	%TEM	TEM mm	%TEM
Triceps	0.30	3.23	0.40	2.65
Subscapular	0.36	3.27	0.36	3.24
Biceps*	0.23	5.11	0.29	4.46
Iliac Crest*	0.62	3.88	0.83	7.35
Supraspinale	0.34	4.86	0.40	4.08
Abdominal	0.62	3.90	0.87	5.76
Front Thigh	0.47	4.12	0.64	2.79
Medial Calf	0.28	3.68	0.45	3.31
Sum of 6 (−*)	0.93	1.49	1.52	1.73
Theoretical	1.01	1.62	1.35	1.55

In the O-Scale System, the sum of skinfolds at triceps, subscapular, supraspinale, abdominal, front thigh, and medial calf sites scaled to a common stature is expressed as a stanine rating for separate norms for males and females yearly age 6 to 18, 19 and 20, and in five year increments thereafter until age 70. The rating is only an indicator of relative adiposity. This is interpreted by comparison with a proportional body weight stanine rating, i.e. the subject's obtained body weight (w) scaled to a standard stature (170.18 cm) raised to the third power, $w (170.18/h)^3$.

As shown in a client print out shown in *Fig. 1* to *4* the O-Scale System provides for three tired comparisons. The first provides for comparison of adiposity and proportional weight in reference to norms for the subject's age and sex. The second provides a raw score summary of eight skinfolds, ten girths, two bone breadths and four skinfold corrected girths relative to the 4th, 50th and 96th percentiles which provides a window on the norms. The third tier provides a proportionality profile of individual items scaled to the subect's stature-adjusted age and sex norm. When the A rating exceeds the W rating, one looks to the individual proportionality profile and expects some dominance of the individual and regional skinfolds. If, on the other hand, the proportional weight rating is dominant, one expects, in the most recent version, the pattern of ten girths, two bone breadths and four skinfold corrected girths will show the individual structures contributing to the dominance. A fourth page provides an explanation of the system for the client.

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O-Scale Rating For : spski
Date   : 23/10/74
Age (decimal years)   : 17.2
Height (centimeters)   : 173.1
Weight (kilograms)   : 68.2
Sum of 6 Skinfolds (millimeters)   : 48.9
Proportional Sum of 6 Skinfolds (mm) : 48.1
Proportional Weight (kilograms)   : 64.8

```
 ..1..|..2..|..3..|..4..|..5..|..6..|..7..|..8..|..9..|
A                                *
     .....|.....|.....|.....|.....|.....|.....|.....|.....|
W                                     *
     .....4%...11%...23%...40%...60%...77%...89%...96%....
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A-Rating : This is your Adiposity rating based on the pro-
            portional sum of six skinfolds compared to your
            age and sex norm. It is your 'fatness' rating.
W-Rating : This is your Proportional Weight rating. This
            is compared to your age and sex norm. It is a
            rating of Weight for Height, NOT of 'fatness'.
The A and W ratings give a general description of physique.
A difference between the A and W ratings is an indication
of your musculo-skeletal development. A more detailed des-
cription of physique is provided by the size listings and
proportionality profile which follow.

KINEMETRIX   (Serial # 52100)

| SIZE PROFILE | | | | |
| Male age 17.2 | | Norm Percentiles | | |
	Present	4%	50%	96%
Weight	68.2	51.9	67.3	82.0
Height	173.1	167.1	176.3	189.8
Skinfolds				
Triceps	8.4	4.9	8.0	20.5
Subscapular	8.8	5.5	8.1	19.2
Supraspinale	5.2	3.5	6.0	20.2
Abdominal	7.7	4.9	9.1	34.0
Front Thigh	10.8	6.9	10.8	25.7
Medial Calf	8.0	4.4	8.0	17.1
Girths				
Arm (relaxed)	28.8	24.2	28.7	33.2
Arm (flexed)	31.4	27.1	31.2	35.0
Forearm (maximum)	26.8	24.7	27.0	29.7
Wrist	17.0	15.6	17.1	18.6
Chest	93.5	80.9	91.5	101.0
Thigh	54.4	47.7	54.2	63.2
Calf (maximum)	36.1	32.4	36.4	41.0
Ankle	22.2	20.2	22.7	25.2
Widths				
Humerus	7.4	6.4	7.0	7.8
Femur	9.7	8.8	9.8	10.6
Corrected Girths				
Arm	26.2	22.2	25.6	29.7
Chest	90.7	78.5	88.3	97.9
Thigh	51.0	44.4	50.2	58.5
Calf	33.6	29.7	33.2	37.5

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Fig. 1   *Fig. 2*

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                 PROPORTIONALITY PROFILE
    Your measurements are scaled to a common stature and then
    plotted relative to your age and sex norms.


                            4%        50%        96%
    Weight             .......|.........|.....*...|.................

      Skinfolds
    Triceps            .......|.........|.*.........|.................
    Subscapular        .......|.........|.*.........|.................
    Supraspinale       .......|...*.....|.........|.................
    Abdominal          .......|....*....|.........|.................
    Front Thigh        .......|......*..|.........|.................
    Medial Calf        .......|.........*.........|.................

      Girths
    Arm (relaxed)      .......|.........|.*........|.................
    Arm (flexed)       .......|.........|.*........|.................
    Forearm (maximum)  .......|.........|.*........|.................
    Wrist              .......|.........|.*........|.................
    Chest              .......|.........|...*.....|.................
    Thigh              .......|.........|.*........|.................
    Calf (maximum)     .......|.........|..*.......|.................
    Ankle              .......|.........*.........|.................

      Widths
    Humerus            .......|.........|.......*..|.................
    Femur              .......|.........|..*........|.................

      Corrected Girths
    Arm                .......|.........|..*......|.................
    Chest              .......|.........|....*....|.................
    Thigh              .......|.........|..*......|.................
    Calf               .......|.........|..*......|.................
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KINEMETRIX   (Serial # 52100)

Fig. 3

THE O-SCALE PHYSIQUE ASSESSMENT SYSTEM

More information on your O-SCALE SYSTEM physique assessment is presented below. Please ask your health, diet or fitness professional if you do not understand any part of the print-out. Page 1 displays and explains your ratings of Adiposity (A) and Proportional Weight (W). Both A and W ratings are scaled from 1 to 9. A rating of 1 indicates that you are in the bottom 4% of the norm, while a 9 indicates that you are in the top 4%. A rating of 5 would rank you in the middle 20%. The percentiles associated with each rating are on the graphic display.
The A and W ratings are not necessarily the same. If they are, it means the individual has an average amount of adiposity ('fatness') for someone of that weight. In more active people, the proportional weight rating is usually higher than the adiposity rating. In this situation, the higher weight rating is not a result of the individual's 'fatness' and must therefore be due to greater development of some other body component(s). Greater activity level would cause an increase in muscularity, and possibly bone mass. An A-rating higher than the W-rating would indicate low musculo-skeletal development for someone of that body weight.

The Size Profile lists your measurements along with selected values for your age and sex norm. The Proportionality Profile conveys different information about your physique. Everyone is scaled to the same height, the scaled values allow comparisons between individuals to be made. This is important, as it is possible to be small in size, yet large in body proportions. Short people tend to be proportionally heavier and more squat than tall people. The proportionality profile is particularly useful in repeated assessments when a change in your physique has occurred. The profile reveals the pattern of change, which may not be uniform throughout your entire body.

One commonly asked question is 'What is ideal?'. There are no A and W ratings ideal for all individuals. The O-SCALE SYSTEM explains your physique status at the time of measurement. Your health and fitness professional will use his or her experience to guide your future training or dietary regime. If a change in your physique is expected, then re-measurement at a future date will give a precise, unbiased view of these changes. Use the O-SCALE SYSTEM to monitor these changes in your body due to dietary and/or exercise program modification.

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Fig. 4

While we recognize the sum of six skinfolds sampling upper and lower limbs and torso is a stable and useful measure of relative adiposity, we do not advocate its use as a single indicator. The sum does not obviate the need to look at the individual proportionality pattern. The proposition that an arbitrary weighting of four upper body skinfolds be used to indicate adiposity assumes (1) the sites selected are representative of over all adiposity in all subjects and (2) there is an optimal weighting for each contributing site and some biologically appropriate criterion to make this decision. There is no evidence to support this proposition and what limited direct anatomical evidence there is suggests there must be a regional sampling to account for individual differences in subcutaneous adipose tissue deposition.

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