

ANTHROPOMETRIC PROFILE OF FEMALE GYMNASTS

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Certain body types may be advantageous for championship performances. Tanner (1964) has even suggested that there exists a strong relationship between the mechanical and physiological requirements of a particular event and the physique of successful participants. Physiological and anthropometric profiles have been developed to describe the qualities and characteristics of elite athletes in their respective sports (see Wilmore, 1983). Such data can be useful in identifying areas of training that should be emphasized and those areas that require little, if any attention. Descriptive profiles also provide data against which information from aspiring athletes can be compared for the identification and selection of potential championship athletes.

Little anthropometric data are available on gymnasts and even less exists pertaining to women gymnasts (see Kreighbaum, 1983, for a review). Sinning (1978; Sinning & Lindberg, 1972) collected data on five Springfield College (SC) women's gymnastics teams at a time when these teams dominated women's gymnastics (1970-1974). This research found women gymnasts to comprise a distinct physical group (also see Parizkova & Poupa, 1963; Pool, Binkhorst & Vos, 1969). The purpose of the present study was to provide further anthropometric data on highly skilled collegiate female gymnasts with reference to norms for other gymnasts, dancers, and nonathletes of the same age.

METHOD

Subjects

Anthropometric data were collected as part of ongoing research on teams from the two top American women's gymnastics programs: the University of Denver (DU; Denver) and The Pennsylvania State University (PSU). Circumference, skeletal diameter, and skinfold measurements were collected on the 1980 DU team (n = 8); hydrostatic weight and skinfold measures were gathered on the PSU teams of 1979 (n = 6) and 1981 (n = 8). Each school has won national championships in the Association of Intercollegiate Athletics for Women (AIAW). The 1980 DU team won the Intermountain AIAW Division II Championships and placed 2nd in the AIAW Division II National Championships. The 1979 PSU

*All data from University of Denver gymnasts were collected by the author. All data from The Pennsylvania State University gymnasts were collected by Larry Barlett and James Hodgson of the No11 Laboratory for Human Performance Research.

team won the Eastern AIAW Division I Championships and placed 4th in the AIAW Division I National Championships. The 1980 PSU team was the AIAW national champions but no data were collected that year. The athletes described were highly skilled and comparable to the Springfield College gymnasts described by Sinning (1978). Only gymnasts actually participating in the national championships served as subjects.

Measurements

Anthropometric measures were obtained using traditional sites and procedures (Behnke, 1961; Behnke & Wilmore, 1974; Maas, 1974; Ross & Marfell-Jones, 1983; Sinning, 1978). Skinfold measures were taken on standing subjects using a Lange caliper calibrated to 10 g/cm². Diameters were measured with a Swiss GPM and circumferences were measured with a 1/4-inch linen Lufkin tape (frequently checked for accuracy). Using independent repeated measures, all skinfolds were measured to an accuracy of $\pm 5\%$ while circumferences and diameters were measured to an accuracy of $\pm 1\%$. The mean of two measures within this range was recorded for data analysis. Body composition estimates of the DU gymnasts were obtained using Sinning's (1978) regression equation for college female gymnasts. The PSU estimates used hydrostatic weighing with measured residual volumes (via nitrogen washout). Circumference somatograms were constructed to represent body segment proportionality considering the gymnast's segment dimensions in relation to her overall size and shape as well as the dimensions of the reference population (Behnke & Royce, 1966; Behnke & Wilmore, 1974). The reference population for this study consisted of 128 women students at the University of California. Their body composition characteristics are shown in Table 1 and their circumferences are listed in Table 3. Gymnast circumferences (c) were divided by individual segment conversion constants (k) from the reference population to derive a deviation value (d) for each circumference (i.e., $d = c/k$). A reference value (D) was obtained by summing all of the segment circumferences and dividing by 100 (i.e., $D = c \text{ total}/100$). The percent deviation of each gymnast circumference from the reference value (D) was obtained by subtracting D from d and then dividing by D. The calculated percent deviation from the segmental norm was then used to graphically illustrate patterns of body segment proportions.

RESULTS AND DISCUSSION

Age, height, body mass, body density, relative fat, and lean body mass for three women's gymnastics teams are presented in Table 1. These data are also combined and compared with other competitive gymnastics teams, norms for college-age women, norms for other young women, and other similar populations (i.e., ballet dancers, body builders and airline stewardesses). Although the gymnasts measured in this study were slightly younger and lighter than the norms developed by Sinning (1978), height, density and relative fat were nearly identical. Furthermore, almost all skinfold, circumference and diameter measures from the DU gymnasts closely matched those of the SC gymnasts. It seems that collegiate championship teams possess

Table 1. BODY COMPOSITION

Measure	Univ. of Denver (n=6) April 1980			Penn State Univ. (n=6) May 1979			Penn State Univ. (n=8) April 1981			Combined Teams (n=22) Collegiate Gymnasts		
	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
Age (yrs)	20.3	1.3	18.8 - 22.2	19.7	1.0	18.3 - 21.5	20.5	1.2	18.8 - 21.8	20.2	1.2	18.3 - 22.2
Height (cm)	161.0	5.0	154.9 - 167.6	159.5	4.7	154.7 - 167.6	158.0	5.6	151.0 - 168.7	159.5	5.1	154.7 - 168.7
Body Mass (kg)	54.0	6.9	42.6 - 62.1	51.07	4.7	43.5 - 56.6	48.7	4.8	42.2 - 56.6	51.2	5.9	42.2 - 62.1
Body Density (g/ml)	1.068	-0.013	1.045 - 1.080	1.062	-0.008	1.052 - 1.072	1.062	-0.011	1.044 - 1.077	1.064	-0.011	1.045 - 1.080
Relative Fat (%)	13.3	6.3	8.0 - 25.0	16.1	3.1	12.2 - 20.2	16.1	4.3	10.2 - 23.4	15.1	4.8	8.0 - 25.0
Lean Body Mass (kg)	47.2	4.8	41.0 - 54.5	41.5	2.5	38.2 - 44.4	40.7	3.8	36.6 - 46.6	43.1	5.1	36.6 - 54.5

Measure	Competitive Gymnasts										College Women			Young Women			Similar Groups		
	1979-1981 DU & PSU Combined	1970-1975 Springfield College	1976 Czech Team	1976 U.S. Olympic Team	1979 U.S. National Modern Rhythmic Team	1977 College Fresh Norms	1976 Make Forest Univ.	1973 Queens College	1970 U. of California	1967 Temple University	1963 Young Women	1968 USAF Young Women	1982 Prof. Ballet Dancers	1983 Cleveland Ballet Co.	1983 Female Body Builders	1971 Stewardesses			
Number of Subjects	22	44	5	5	7	1533	83	69	128	99	94	32	29	10	422				
Age (yrs)	20.2	19.4	19.0	17.2	20.7	18.2	20.2	20.3	21.4	19.4	20.4	20.3	24.9	27.0	22.1				
Height (cm)	159.5	160.6	163.5	162.3	162.1	165.8	166.2	160.4	164.9	163.1	167.5	164.1	164.3	160.8	163.2				
Body Mass (kg)	51.2	53.7	52.5	56.5	53.3	59.2	57.5	59.0	58.6	56.4	59.0	55.8	49.0	53.1	52.8				
Body Density (g/ml)	1.064	1.064				1.043	1.043	1.039	1.041	1.031	1.034	1.034		1.069					
Relative Fat (%)	15.1	15.3	12.9	16.8	11.2	23.9	24.9	25.5	25.7	31.0	28.7	27.9	16.9	13.2					
Lean Body Mass (kg)	43.1	45.4	45.8	46.9		45.0	43.7	44.0	43.4				45.3	46.6					

SOURCE:

- NOTE: 1 = Stimming, 1978; 2 = Novak, Woodward, Bestitt, & Mellerowicz, 1977; 3 = Sprymarova & Parizkova, 1969; 4 = Webb, Millan, Stoliz, 1979; 5 = Case, Fleck, & Koehl, 1980; 6 = Zuti, & Corbin, 1977; 7 = Jackson & Pollock, 1976; 8 = Katch & McArdle, 1973; 9 = Wilmore & Bemke, 1970; 11 = Young, Martin, Tensuan, & Blondin, 1982; 12 = Clauser, Tucker, McConville, Churchill, Laubach, & Beardson, 1972; 13 = Cohen, Kim, May, & Ertel, 1982; 14 = Calabrese, Kirchner, Floyd, Rapoport, Williams, Welker, & Bergfeld, 1983; 15 = Freedson, Athletic, Loucks, & Girandola, 1983; 16 = Snow, Reynolds, & Allgood, 1975.

similar anthropometric characteristics and that these characteristics are distinctly different from the norms for college-aged women.

Stature and Body Mass

Female gymnasts have been described as short and light relative to most other female populations (Carter, 1970; Falls & Humphrey, 1978; Hirata, 1966; Medved, 1966; Parizkova & Poupa, 1963; Pool et al., 1969; Sinning & Lindberg, 1972; Sprynarova & Parizkova, 1969). Similar results were obtained in this study. Relative to the norms of female college freshmen (Zuti & Corbin, 1977), women gymnasts are at the 25thile for height, 23rdile for body mass, and 6thile for body fat. Collegiate female gymnasts are approximately 6 kg lighter and 5 cm shorter than other women their age. They are also slightly shorter than international class gymnasts who have already been described as the smallest of all Olympic participants (Medved, 1966). Competitive female body builders were the only group found to share a similar stature and weight.

Body Fat and Skinfoldds

Women gymnasts are characteristically lean (Parizkova & Poupa, 1963; Sinning, 1978; Sinning & Lindberg, 1972). Based on the norms shown in Table 1, college women might be described as having 25% body fat. Women gymnasts have 15% body fat. Since some feel that 14% body fat is essential for women (Behnke & Wilmore, 1974), these athletes have extremely little subcutaneous fat. The percentage body fat of college-age female gymnasts is considerably lower than non-athletes and lower than many other athletes as well (Plowman, 1974; Wilmore, 1983). It seems that performance and relative body fat are highly related. Using the results of an AIAW regional championship, Falls and Humphrey (1976) found a significantly higher percentage of body fat in non-place winners than place-winners. Skinfold measures and performance are also negatively correlated (Pool et al., 1969).

Skinfold measures are presented in Table 2 relative to other population norms with percentile rankings where available. The results support other findings that female gymnasts have extraordinarily small skinfoldds (e.g., Parizkova & Poupa, 1963; Plowman, 1974; Pool et al., 1969; Sinning & Lindberg, 1972). All measures were similar to those collected on the SC gymnasts (Sinning, 1978), except for the DU gymnasts who had smaller fatfoldds covering the triceps, supra-pubis and gastrocnemius. Both sets of gymnasts had similar skinfoldds to ballet dancers and body builders, except the body builders had considerably larger waist skinfoldds and smaller thigh skinfoldds. All values for the athletes were considerably lower than the norms for college and USAF women, most by approximately 50%. The most pronounced difference was found near the umbilicus where the gymnasts had approximately 8 mm and the college women had about 21 mm.

Table 2. SKINFOLDS (mm)

Location	Univ. of Denver April 1980			Competitive Gymnasts		College Women			Other		Norms		Stewardess Xite Rank for Denver Gymnasts	Airline Stewardesses	Stewardess Xite Rank for Denver Gymnasts
	Range	SD	Mean	1970-1975 Springfield College	1972 Olympics A Nonplacng Team	1976 Wake Forest Univ.	1973 Queens College	1970 Univ. of Calif.	1983 Cleveland Ballet Company	1983 Pro Body Builders	1968 USAF Women	1905			
Number of Subjects				44	5	83	69	128	29	70	1905	422			
Traps	4.0-12.0	2.8	7.0												
Scapula	4.0-14.0	3.1	7.8	7.9	6.5	15.3	18.8	13.2	7.8	9.5	12.9	10			
Triceps	5.0-13.0	3.2	8.4	12.0	12.1	18.8	21.6	12.8	9.7	9.6	19.0	1	14.4	1	
Kidney	10.0-35.0	9.8	19.2												
Chin	3.0- 7.0	1.3	5.2	5.5				5.5							
Throat	2.0- 4.0	0.7	2.8												
Pectoral	10.0-25.0	6.3	17.0			14.0									
Biceps	2.0-10.0	2.7	3.9		4.1										
Mid-Axillary	3.0-12.0	2.9	6.4	5.9		13.3		10.7							
Supra-Iliac	4.0-19.0	6.1	9.2	9.7	7.6	15.3	26.8	17.2	9.2	8.0	19.7	8	9.9	43	
Supra-Iliac HC	2.0- 8.0	2.0	4.8	6.6											
Sub-Umbilicus	2.0-14.0	4.4	7.4	8.5	5.9	22.8	25.0	15.1	9.0	16.4					
Supra-Pubis	2.0- 8.0	2.1	4.1	8.5											
Quadriceps	8.0-30.0	6.6	15.6	17.8	13.0	28.8	29.8	31.8	14.4	8.7					
Mid-Inner Thigh	5.0-34.0	9.1	19.2												
Patella	3.0- 6.0	1.1	5.0					7.0							
Gastroc	4.0-13.0	3.0	8.8	16.4	7.6						15.9	9			

NOTE: Sources listed in Table 1.

Based on USAF norms for women, collegiate women gymnasts rank very low in skinfolds for the arm (1%ile), waist (8%ile), calf (9%ile) and back (10%ile).

An interesting finding relates to the differential distribution of fatness. Airline stewardesses represent a lean population; thus, it was not surprising to find that they have skinfolds at the waist similar to gymnasts. However, tricep skinfolds for the gymnasts were in the 1st percentile for stewardesses. Pronounced racial differences in fat distribution, similar to those reported by Malina, Mueller, Bouchard, Shoup, and Lariviere (1982), were also apparent.

Circumferences

Circumference measures and percentile rankings are shown in Table 3 relative to other population norms. The DU results closely matched the SC results except that the DU gymnasts had slightly larger neck and shoulder girths with slightly smaller lower leg girths. Circumferences for the gymnasts were also similar to those of professional body builders except for the chest. Over-the-breast measures for the body builders (90.6 cm) were much larger than the gymnasts (84.9 cm). Relative to other college women, the gymnasts' girth measures were smaller around the head, chest, waist, hips, thighs, calf and ankle, but larger around the high chest and biceps. Relative to USAF women, gymnasts have small girth measures around the head, neck, hips and legs with very large measures around the shoulders, upper chest and upper arms. However, compared to slender stewardesses, the gymnasts have small girth measures around the hips and ankles, but extremely large measures around the neck, shoulders, thighs and biceps. Sinning and Lindberg (1972) also found college gymnasts to be smaller in girth of the hips than college women.

Figure 1 is a circumference somatogram of the Denver gymnasts, Springfield College gymnasts, and professional body builders relative to women students at the University of California (Wilmore & Behnke, 1970). As a quantitative representation of body shape (segment proportionalities), this somatogram shows the similarity of three populations and their percent deviations from the reference norm. Relative to college women, gymnasts and body builders have large upper torsos and arms--suggesting muscular hypertrophy in these areas--with slender hips and legs. The exceptions to this trend appears in the chest, calf and waist circumference. The DU gymnasts have proportionally large girths above and below the breasts, but only average measures over the breasts. Body builders, however, have large girth measures over the breasts. The DU gymnasts and body builders both

Table 3. CIRCUMFERENCES (cm)

Location	Competitive Gymnasts			College Women				Norms		Aerline Stewardesses		Stewardess Kite Rank (%)			
	Univ. of Denver April 1980	1970-1975 Springfield College	1972 Olympics A Nonplacing Team	1976 Wake Forest Univ.	1973 Queens College	1970 Univ. of Calif.	1983 Pro Body Builders	1968 USAF Women	USAF Kite Rank Denver Gymnasts (%)	1971 Aerline Stewardesses (%)					
	Range	SD	Mean												
Number of Subjects	51.5-55.0	1.3	52.9	44	5	83	69	56.2	128.0	10	1905	54.9	13	422	
Head	29.5-34.0	1.6	31.8	30.6			55.0		31.8		54.9	33.8	13	29.9	93
Neck	94.0-109.5	4.6	101.7	99.8			101.9		101.9	101.7	100.4	63	63	95.5	99
Shoulders	78.5-94.5	4.9	85.9	86.4			85.2		85.2	90.6	84.2	68	68	85.6	42
Chest (Breasts)	78.0-93.5	4.9	84.9				87.8		87.8	90.6	89.7	20	20	85.6	
Chest (Below Breasts)	70.0-81.0	3.4	73.0	73.3			74.1		74.1	64.5	74.3	43	43	62.2	83
Abdomen (Waist)	58.0-69.0	4.7	64.9	64.9			67.1		67.9	69.7	67.2	37	37	62.2	
Abdomen (Umbilicus)	60.5-75.5	5.5	68.6	70.9			80.4		75.3	69.7	67.2	37	37	62.2	
Hips (Pubis)	81.0-93.0	4.1	87.8	89.2			94.1		95.9	87.0	95.3	10	10	90.1	25
High Thigh	45.5-59.5	4.6	53.6							87.0	55.5	33	33	46.2	99
Mid Thigh	44.5-56.0	3.8	51.0	52.9	48.1		56.5	55.4	57.0	53.0	55.5				
Low Thigh	38.0-48.0	3.4	43.9												
Knee	29.5-35.0	1.7	31.8	34.1			36.5	36.1	36.1	33.4	36.3	2	2	32.2	58
Gastroc	18.0-21.0	1.2	19.8	20.4			20.8	21.9	21.1	20.3	21.1	17	17	20.1	36
Ankle	23.0-28.5	2.2	26.1	25.0	24.7		27.0	25.0	25.0	25.8	25.6	63	63	23.3	99
Relaxed Bicep	24.5-31.0	2.3	28.2	27.4	26.8		23.8	26.0	23.5	24.0	23.5	50	50	24.6	99
Flexed Bicep	21.0-25.8	1.6	23.4	23.7	22.8		14.8	16.1	14.9	15.1	15.0	25	25		
Forearm	13.3-15.5	0.8	14.4	14.7											
Wrist															

NOTE: Sources listed in Table 1.

SOMATOGRAM

Percentage Deviation From Proportional Norm

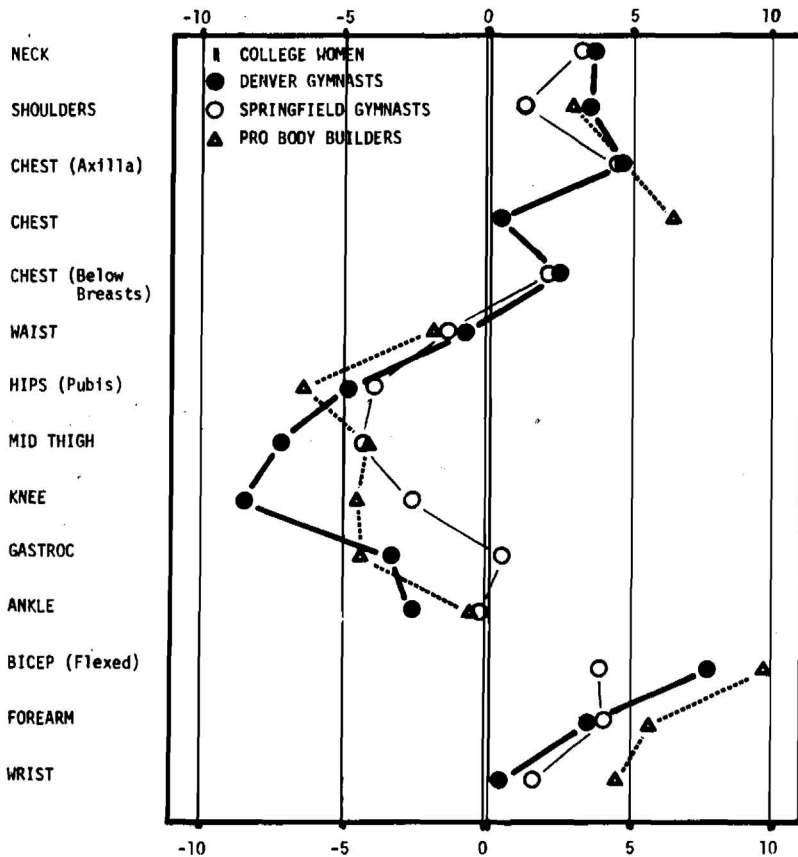


Figure 1. Circumference somatogram illustrating the proportional relationship of three populations (University of Denver Women Gymnasts, Springfield College Women Gymnasts, and Professional Body Builders) expressed in percentage deviation from a reference population of college women (University of California students -- Wilmore & Behnke, 1970).

SOMATOGRAM

Percentage Deviation From Proportional Norm

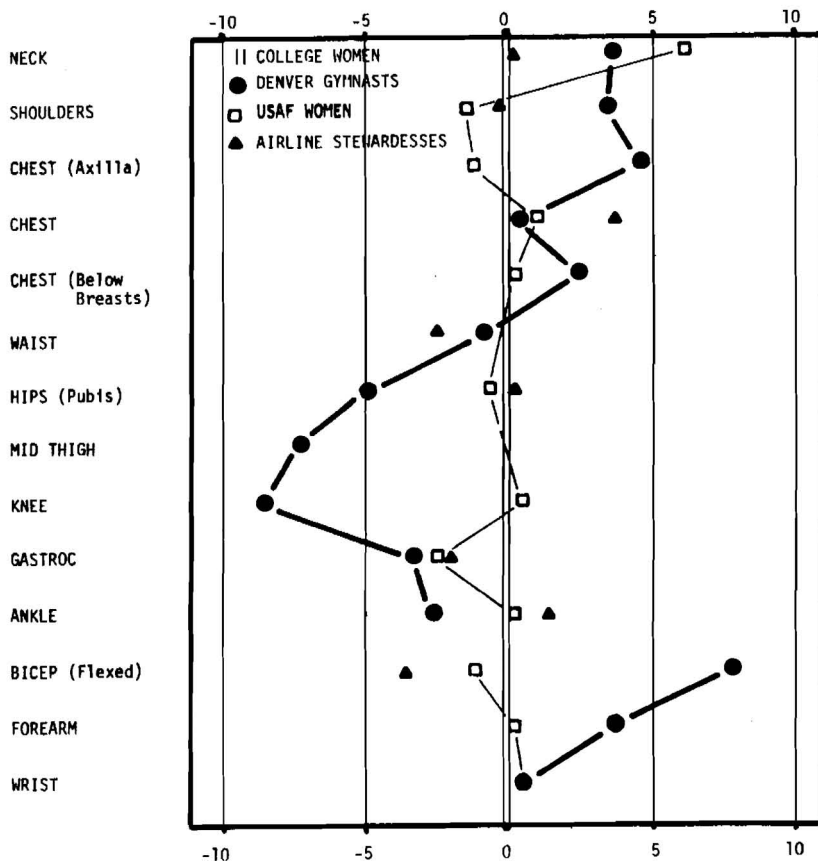


Figure 2. Circumference somatogram illustrating the proportional relationship of three populations (U. of Denver Gymnasts, USAF Women, and Airline Stewardesses) expressed in percentage deviation from a reference population of college women (U. of California students -- Wilmore & Behnke, 1970).

have smaller gastrocnemius girths than the SC gymnasts. The DU gymnasts' ankles were slender compared to the SC gymnasts and body builders.

The somatogram deviations in Figure 1 suggest that there exists regional specificity with regard to the location of muscular hypertrophy and that the pattern is similar for both populations of gymnasts and the body builders.

Figure 2 illustrates segmental proportionalities of the Denver gymnasts, USAF women, and stewardesses relative to women students at the University of California (Wilmore & Behnke, 1970). The somatogram suggests the USAF women and stewardesses have proportional circumferences similar to college women. Gymnasts, in contrast, have larger upper bodies and arms with smaller lower bodies. With the exception of a large neck girth and small calf girth, USAF women closely resemble college women. Compared to college women, airline stewardesses have a proportionally larger chest (at breasts) with a smaller waist, lower legs and upper arms.

Diameters

Diameter measures and percentile ranks are presented in Table 4 relative to other population norms. The present data closely matches those of the Springfield College gymnasts and body builders, except with regard to biiliac measures where the body builders had narrower upper hips than the gymnasts. Gymnasts and college women have similar diameters except gymnasts have narrower biacromial, chest width, biiliac and bitrochanteric measures.

Percentile rankings of the Denver gymnasts with USAF women and stewardesses suggest distinct proportional difference. Using the USAF norms, extreme shoulder muscle hypertrophy is evidenced by the gymnasts' narrow biacromial measures (3%ile) and large bideltoid measures (64%ile). Chest width was very narrow relative to USAF women (1%ile), but average for stewardess norms. Gymnasts appear to have broad and shallow waists relative to USAF women since their abdominal width was high (75%ile), while their abdominal depth was low (18%ile). Since stewardesses have slender waists, both abdominal width (99%ile) and depth (76%ile) were very high.

Somatotype

Gymnasts have been described as lighter, stronger by body mass, leaner and more flexible than all other athletes (Montpetit, 1976). Studies on female national and Olympic gymnastics champions have characterized these athletes as being exceptionally high in mesomorphy compared to women in general, and even relative to other female athletes (Carter, 1970; Falls & Humphrey, 1978; Hirata, 1966; Sinning & Lindberg, 1972). Because these athletes are also low in body fat, Plowman (1974) describes female gymnasts as small, neat ectomesomorphs. Falls and Humphrey (1978) found higher endomorphic and lower mesomorphic ratings for the nonplacers and nonathletes than

Table 4. SKELETAL DIAMETERS (cm)

Location	Competitive Gymnasts			College Women			Norms		1971 Airline Stewardesses	Stewardess %ile Rank (% For Denver Gymnasts)
	Univ. of Denver April 1980	1970-1975 Springfield College	1972 Olympics A Nonplacng Team	1976 Wake Forest Univ.	1973 Queens College	1970 Univ. of Calif.	1983 Pro Body Builders	1968 USAF Women		
	Range	SD	Mean							
Number of Subjects			8	44	5	83	69	128	10	
Head Length	17.8-19.1	0.4	18.3					19.0		45
Head Width	13.5-14.6	0.4	14.1					14.9		18
Biacromial	30.3-35.4	1.7	32.7	34.9	36.7	36.8	40.4	36.5	32.1	5
Bideltoid	39.5-46.4	2.0	42.5			41.4		42.1		77
Chest Width	20.5-27.0	1.8	24.0	24.1		27.8	29.0	25.8	25.6	50
Chest Depth	14.6-18.6	1.4	16.6	16.3						99
Abdom Width	22.0-26.3	2.1	25.3							76
Abdom Depth	14.0-17.0	0.9	15.6							76
Pilliac	25.6-27.7	0.7	26.3	26.2			28.2	28.4	23.1	
Bitrochanteric	27.7-30.9	1.2	29.6	30.2		34.0	32.1	32.2	28.6	
Bicondylar	7.9- 8.8	0.3	8.5	8.3	8.6	9.3	8.8	8.9	8.3	30
Ankle	5.8- 6.6	0.3	6.2	6.1	6.8	6.1	5.1	6.3	5.4	15
Elbow	5.6- 6.5	0.3	5.9	5.8	6.3	5.1	6.2	6.0	6.0	40
Wrist	4.7- 5.2	0.2	4.9	4.9	5.4	5.1	5.1	4.9	4.9	34
Arm Span	15.3-17.4	1.9	166.0					165.8		40
Hand Length	15.3-18.9	1.3	17.5					17.3		58
Foot Length	21.1-24.7	1.2	23.0					24.0		
Leg Length	77.0-90.0	5.3	83.5							
Hand Width	6.8- 7.9	0.4	7.4							
Foot Width	7.7- 9.6	0.6	8.7							

NOTE: Sources listed in Table 1.

placers in a collegiate regional championship. They conclude that "certain body types may be requisite for championship performance in women's gymnastics" (p. 43). They also speculate economy and grace of movement are achieved by gymnasts' lower relative fat and endomorphy, that greater dynamic strength is correlated with their higher mesomorphy, and that ectomesomorphic body types are more aesthetically pleasing to gymnastics judges.

The higher body densities of women gymnasts to other norms (Table 1) suggests these gymnasts possess greater muscularity. Similar to female professional body builders, collegiate female gymnasts appear to have disproportionately well-developed upper torsos. Using the USAF women norms, latissimus dorsi hypertrophy is reflected in the narrow chest width (1%ile), but large chest axilla circumference and the distinct drop in chest circumference from the axilla (68%ile) to the breasts (20%ile). Shoulder muscle development is evidenced by the difference in narrow biacromial diameter (3%ile) and the large bideltoid diameter (64%ile). Ranking in the 78%ile on the flexed bicep circumference measure, while having a tricep skinfold in the 1%ile, suggests the gymnasts have considerable upper arm muscular hypertrophy. These athletes also appear to have a high muscle mass which is disproportionately concentrated in the upper trunk and shoulder girdle.

Such unique physique characteristics may provide a biomechanical advantage for arm support and inverted balancing activities (Christensen, 1979; LeVeau, Ward & Nelson, 1974; Parizkova & Poupa, 1963; Pool et al., 1969; Salmela, 1979; Sinning & Lindberg, 1972). For instance, "the small stature observed among gymnasts results in a smaller moment of inertia about an axis in the transverse plane through the mass center when compared with larger athletes" (LeVeau et al., 1974, p. 150). Presumably, this makes a smaller person better able to perform spinning movements while in free flight. On the other hand, upper body muscular hypertrophy results in an elevated center of gravity which is a disadvantage for upright balancing and stability (Hay, 1978).

CONCLUSIONS

Highly skilled American collegiate female gymnasts comprise a special population according to anthropometric characteristics. Relative to other college-aged women and other female athletes, women gymnasts tend to be shorter in stature, lighter in body mass and higher in body density. These athletes may be described as having ectomesomorphic body types. They have extraordinarily small skinfolds with disproportionate upper body muscle hypertrophy. Their anthropometric characteristics are unique, but in some respects similar to those of competitive body builders and professional ballet dancers.

These findings may be useful in the identification and selection of potential championship athletes, training diagnostics, and equipment design. Such findings also suggest that special consideration be given to the unique physiques of women gymnasts when doing kinetic analysis of gymnastics movements.

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