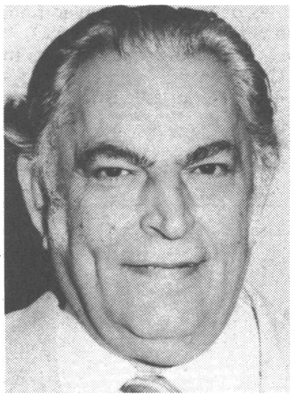

T. Khosla

AGE, HEIGHT AND WEIGHT OF FEMALE OLYMPIC FINALISTS

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ABSTRACT

Age, height and weight are intricately related to performance in a specific sporting activity. Optimum standards derived from 32 female Olympic finalists from two jumping events are listed as a sample from a much larger set of 824 finalists from 47 events. An example of variation is that high jumpers are taller by 6.3 cm and younger by 2.9 years than long jumpers. Conversely, considerable variation in body weight is shown for a group of finalists all with a height of 171 cm. The weights of these finalists range from 56 kg for a 400 m runner to 85 kg for a discus thrower. Many other events are listed between these examples and a number of events are found to share the same combination of height and weight (height 171 cm, weight 59-62 kg) swimming freestyle and medley, 200 m run, rowing, canoeing, volleyball and handball. These findings are expected to be of use for potential champions looking for optimum standards in specific events. They are also of use for trainers counselling athletes in the most appropriate selection of the event befitting her physique. Many sporting activities are found to be seriously biased in favour of the taller members of the population. This is a cause for concern as is the need for some remedial action.

INTRODUCTION

Tanner (1964) in his study on the physique of male Olympic athletes measured 14 anthropometric variables for about 125 selected athletes from 18 track and field events drawn from several nationalities and races. He also included classification of body form on scales of endomorphy, mesomorphy and ectomorphy. No such data are documented on women athletes and indeed very little information is available on them other than age, height and weight.

Height is highly correlated with various linear body dimensions, and body weight with various breadths, girths and with skinfold measurements. Stoudt et al (1970) have documented correlation coefficients of 17 variables (sitting height erect and normal, knee height, popliteal height, elbow rest height, thigh clearance height, buttock-knee length, buttock-popliteal length, elbow to elbow breadth, seat breadth, biacromial diameter, chest girth, waist girth, right arm girth, right arm skinfold, infrascapular skinfold and sum of skinfolds) with height, weight and age for both men and women in the United States. They also derived multiple regression equations for each of these 17 anthropometric measurements as a function of height, weight and age. Extremely good regression fits for 12 of the 17 variables (with multiple correlation coefficients ranging from .737 to .911) indicate that height, weight and age are together good determinants of a number of aspects of physique.

Every event determines an optimal combination of height and weight. In some events differences are obvious to a novice; basketball players are tall, gymnasts are short, endurance runners are lean (light for height), sprinters are muscular (relatively heavy for height) and the body build of a javelin thrower is markedly different from that for a shotputter. In most other events, however, these factors are not clear even to an expert. Appreciable differences are found within events, for example finalists differ significantly from non-finalists in age, height, and weight for height in several athletic and swimming events (Khosla, 1978; 1984). Consequently optimum standards for age, height and weight derived from finalists rather than from all participants have been published (Khosla and McBroom, 1984) for each of the following 47 Olympic events: archery, athletics — track and field (12 events), basketball, canoeing (3), equestrianism (3), fencing, gymnastics (4), handball, rowing (6), swimming and diving (14) and volleyball.

DATA AND METHODS

Full details on data and methods, are given elsewhere (Khosla and McBroom, 1984). Data on age, height, weight and event for 824 women finalists were collated from six massive volumes published by the organising committees of the summer Olympics held at Munich in 1972 and at Montreal 1976. These volumes are virtually unobtainable in Britain; the British Library, Boston Spa, kindly obtained them on loan from abroad. No such data were published by the Russians in 1980. Surprisingly, even the recently held Games at Los Angeles did not document such data. Our results based on Munich and Montreal Olympics stand unmatched for their rarity.

Comparisons of the heights of 824 finalists from all events with the general population are based on females aged 18-24 in the United States mean height 163 cm, standard deviation 6.1 cm (Abraham et al, 1979), and in Great Britain mean 161.5 cm, SD 6.1 cm (OPCS Monitor, 1981).

Because height and weight are highly correlated, comparisons of body weight need adjustment for height. Body mass index (weight/height^2) is most appropriate as it is uncorrelated with height (Khosla and Lowe, 1967) and is in wide use. Adjusted weight in kilograms (standardised to a height of 165 cm) is another way of expressing the same thing and is easier to interpret directly. It is derived by the formula: adjusted weight (kg) = mass index x (165 cm)^2: so for an athlete of height 170 cm and weight 62 kg, the index is 2.145 g/cm^2 and the corresponding adjusted weight at 165 cm is 58.4 kg. Differences in physique could arise from height alone, from adjusted weight alone, or from both.

Caution is necessary in interpreting the body mass index as it does not account for frame size. Moreover, obesity and extra weight are often dissimilar. Extra weight may be muscle in an athlete but adipose tissue in a more typical person. The body mass index alone cannot distinguish between these possibilities.

RESULTS

The physical characteristics of the finalists are summarised in Table I. It is interesting to find a large variation in age ranging from 14 years for a swimmer to 45 years for a horsewoman in the dressage event. In physical dimensions the finalists can range from a height of 140 cm (55 in) for a coxswain to a towering 210 cm (83 in) for a basketball player. In terms of weight they can be feather light at 38 kg (84 lb) for a gymnast to a super heavy 128 kg (282 lb) for a basketball player. The adjusted weight at 165 cm ranged from 44 kg (97 lb) for a multimedallist gymnast to a 94 kg (207 lb) bronze medallist discus thrower.

Table I Mean, standard deviation and range of age, height, weight and adjusted weight at a height of 165 cm for 824 female Olympic finalists from 47 events.

	Age years	Height cm	Weight kg	Adjusted Weight at 165 cm (kg)
Mean	22.8	170.3	63.7	59.4
S.D.	4.7	7.4	10.8	6.9
Range	14-45	140-210	38-128	44-94

As an example of how the information about Olympic finalists may be used, high jump and long jump are used. An aspirant aiming at the highest level of international competition may compare her own physical characteristics with those listed in Table II. If her age, height, weight, adjusted weight or body mass index deviate far from the ranges observed amongst finalists, she is likely to be severely disadvantaged.

The long jumpers are significantly older than high jumpers by 2.9 years. On average high jumpers are 6.3 cm (2.5 in) taller than long jumpers; such a difference is most unlikely to occur by chance ($p < .001$). The scatter diagram (Fig. 1)

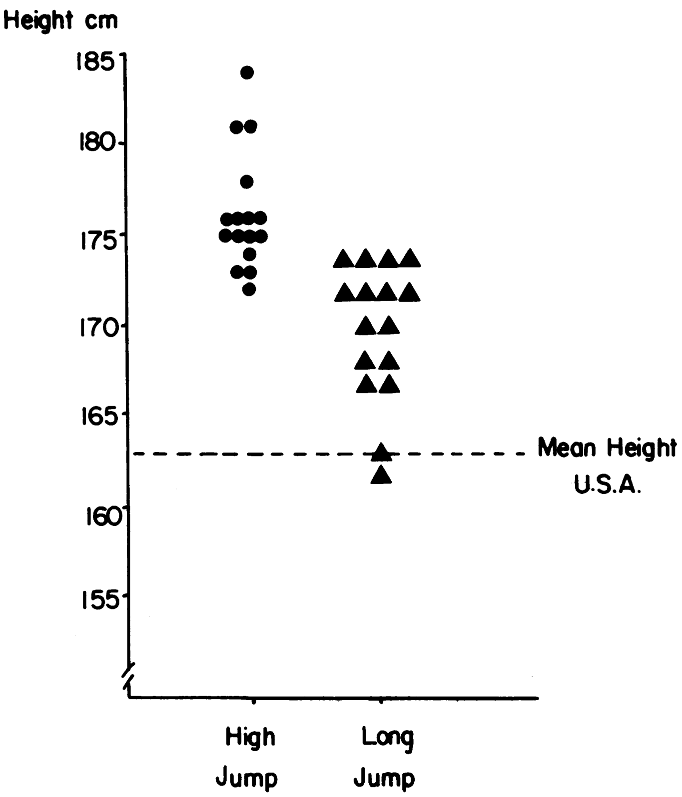

Fig. 1: Scatter diagram of heights of female Olympic finalists from two jumping events.

Table II Height (cm), weight (kg), adjusted weight (kg) at a height of 165 cm, mass index (g/cm²) and age are listed in rank order of placing in final (1 gold, 2 silver, etc.) and year of competition (1972 Munich, 1976 Montreal) from two jumping events. Mean and standard deviation of the variables are given in the last two rows of each table.

ATHLETICS High Jump

Ht. (cm)	Wt. (kg)	Adj. Wt in kg at 165 cm	Mass Index g/cm²	Age	Place	Year
184	70	56.3	2.068	16.3	1	72
175	59	52.4	1.927	24.0	1	76
175	65	57.8	2.122	25.7	2	72
178	61	52.4	1.925	23.0	2	76
181	67	55.7	2.045	25.0	3	72
174	65	58.4	2.147	29.0	3	76
181	68	56.5	2.076	22.9	4	72
172	63	58.0	2.130	30.0	4	76
175	62	55.1	2.024	21.9	5	72
173	61	55.5	2.038	20.0	5	76
176	64	56.3	2.066	19.4	6	72
173	60	54.6	2.005	21.0	6	76
175	59	52.4	1.927	20.4	7	72
176	66	58.0	2.131	18.0	7	76
176	65	57.1	2.098	19.5	8	72
176	67	58.9	2.163	26.0	8	76
Mean 176.2	63.9	56.0	2.056	22.6		
S.D. 3.3	3.3	2.1	0.078	3.8		

ATHLETICS Long Jump

Ht. (cm)	Wt. (kg)	Adj. Wt.	Mass Index	Age	Place	Year
174	66	59.3	2.180	25.6	1	72
174	62	55.8	2.048	25.0	1	76
163	54	55.3	2.032	29.8	2	72
170	57	53.7	1.972	19.0	2	76
172	57	52.5	1.927	26.4	3	72
170	62	58.4	2.145	30.0	3	76
162	56	58.1	2.134	24.6	4	72
174	61	54.9	2.015	22.0	4	76
172	62	57.1	2.096	22.2	5	72
172	58	53.4	1.961	21.0	5	76
168	56	54.0	1.984	23.4	6	72
167	61	59.5	2.187	23.0	6	76
167	55	53.7	1.972	33.1	7	72
172	60	55.2	2.028	27.0	7	76
174	68	61.1	2.246	25.6	8	72
168	56	54.0	1.984	30.0	8	76
Mean 169.9	59.4	56.0	2.057	25.5		
S.D. 3.8	4.1	2.6	0.096	3.8		

The entries on jumping events are extracted from Set A Tables on 47 events; Khosla and McBroom (1984). The entries on most events (field and track, gymnastics, swimming events) are based on 16 Olympic finalists from Munich and Montreal. For group contests such as volleyball, rowing, canoeing, etc., only the members of the medal winning teams were included.

demonstrates that 8 of the 16 long jumpers are shorter than the shortest high jumper (172 cm, 67.7 in). On average, however, even long jumpers are 6.9 cm (2.7 in) taller than the average of the USA reference population ($p < .001$), and for Great Britain this difference is even more pronounced. It is also of interest to note that the finalists form a homogeneous group with a significantly smaller standard deviation for height than that of the general population in the USA and in Great Britain. The variance ratio test for the high jumpers is $F = (6.1/3.3)^2 = 3.42$ $p < .01$. It is notable that mean body mass indexes and hence adjusted weights of the two groups of jumpers are identical.

There is a considerable variation in body weight at a specified height. For example finalists with a height of 171 cm vary in body weight from 56 kg (equestrian dressage, 400 m run) to 85 kg in discus throwing (Table III). It is of interest to note that a number of events show the same combination of height and weight (height 171 cm, weight 59-62 kg); swimming, canoeing, rowing and handball. Table III is extracted from the list of 824 finalists arranged in ascending order of height (1 cm steps) and weight within height (1 kg steps) in the range of observed heights 140 cm to 210 cm. The two sets of tables of which Tables II and III are examples are expected to be of value to coaches, equipment designers, scientists and research workers in sports medicine as well as to potential competitors themselves.

Table III The table lists the physical characteristics of 34 finalists in ascending order of weight (1 kg steps) for a height of 171 cm. The serial order of other variables within height-weight combinations are: age, position in finals (1 gold, 2 silver, etc.), year of competition (1972 Munich, 1976 Montreal), mass index (g/cm²), adjusted weight in kg at a height of 165 cm, and event.

Ht. (cm)	Wt. (kg)	Age	Position	Year	Mass Index g/cm²	Adj.Wt. kg at 165 cm	Event
171	56	32.2	7	72	1.915	52.1	EQUESTRIAN – Dressage
171	56	24.9	2	72	1.915	52.1	ATHLETICS – 400 m Run
171	58	26.0	3	76	1.984	54.0	ATHLETICS – 100 m Run
171	58	26.0	5	76	1.984	54.0	ATHLETICS – 200 m Run
171	59	15.8	1	72	2.018	54.9	SWIMMING – 400 m FS
171	59	15.8	1	72	2.018	54.9	SWIMMING – 200 m Medley
171	59	15.8	1	72	2.018	54.9	SWIMMING – 200 m FS
171	59	15.8	3	72	2.018	54.9	SWIMMING – 100 m FS
171	59	15.8	2	72	2.018	54.9	SWIMMING – 800 m FS
171	60	25.9	2	72	2.052	55.9	VOLLEYBALL
171	60	20.0	5	72	2.052	55.9	ATHLETICS – 200 m Run
171	61	22.6	3	76	2.086	56.8	VOLLEYBALL
171	61	18.8	7	72	2.086	56.8	CANOEING – Kayak 3
171	62	25.7	1	76	2.120	57.7	ROWING – Sculls double
171	62	21.2	9	76	2.120	57.7	CANOEING – Kayak 2
171	62	23.9	2	76	2.120	57.7	HAND BALL
171	64	34.2	3	72	2.189	59.6	ATHLETICS – 100 m Hurdles
171	64	21.3	3	76	2.189	59.6	VOLLEYBALL
171	65	24.4	7	72	2.223	60.5	ATHLETICS – Javelin
171	66	22.0	2	76	2.257	61.4	VOLLEYBALL
171	66	21.3	6	72	2.257	61.4	SWIMMING – 200 m Butterfly
171	66	34.3	1	72	2.257	61.4	VOLLEYBALL
171	67	27.0	2	76	2.291	62.4	VOLLEYBALL
171	67	28.9	3	76	2.291	62.4	HAND BALL
171	67	28.2	2	76	2.291	62.4	VOLLEYBALL
171	68	24.9	9	72	2.326	63.3	CANOEING – Kayak 2
171	68	25.4	3	72	2.326	63.3	VOLLEYBALL
171	69	21.7	4	76	2.360	64.2	ROWING – Sculls single
171	70	30.2	1	72	2.394	65.2	VOLLEYBALL
171	71	22.3	1	72	2.428	66.1	ATHLETICS – 200 m Run
171	71	22.3	1	72	2.428	66.1	ATHLETICS – 100 m Run
171	73	26.3	7	72	2.496	68.0	CANOEING – Kayak 2
171	76	26.4	3	72	2.599	70.8	VOLLEYBALL
171	85	28.0	6	76	2.907	79.1	ATHLETICS – Discus

The entries are extracted from Set B Tables: Khosla and McBroom (1984). The original set lists 824 such entries in ascending order of height 140 to 210 cm, in 1 cm step and weight within height in 1 kg steps.

Figure 2 compares the height distribution of the finalists with the general population from the United States. Of the 824 finalists, 23.3% were observed to have heights of 175 cm or more; in the general population only 2.4% in the USA and 1.4% in Great Britain have such heights. The advantages of being tall is further demonstrated by the ratio (number of finalists/number of women) in Figure 2. These range from 0.14 for the shortest height group to 26.7 in the tallest; which implies that the opportunity to become a finalist is 191 times as great in the latter group as in the former.

DISCUSSION

Physique is just one of the essential factors in a chain of many others (physiology, psychology, motivation, training, coaching facilities, equipment, etc.) in the making of an international champion. A chain can be only as strong as its weakest link. An ideal combination of height and weight for an event is not sufficient by itself but its lack even in the presence of other desirable attributes can be a serious handicap.

According to the "Sport for All" Charter of the Council of Europe (1976) a participant with ambition and ability has the right to become a champion. The Council's objectives are to stimulate sports participation at all levels of performance and to increase the number of participants by encouraging those sections of the community who are not actively engaged in sport. The major height bias demonstrated above appears to show that there is a big gulf between what the charter states and what the sporting bodies do in formulating rules for the games.

There is a need for some remedial action both in the light of the "Sport for All" Charter of the Council of Europe (1976) and also the first charter of the Olympic Games (Law and Dixon, 1970) which states "they assemble the amateurs of all nations in equal and fair competition".

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Height (cm) Middle of interval	Finalists: Number of finalists	Women U.S.A.: Number of women	Ratio Finalists/Population
139	1	0	
142	0	0	
145	0	5	.14
148	1	9	
151	13	29	.45
154	18	58	.31
157	22	106	.21
160	31	130	.24
163	75	155	.48
166	106	137	.77
169	137	98	1.40
172	160	55	2.91
175	117	29	4.03
178	63	10	6.3
181	46	3	
184	21		
187	8		26.7
190	2		
193	3		

Fig. 2: Height distribution of 824 Olympic Finalists from 47 events. The distribution on the right relates to heights of women aged 18-24 years in the general population of the United States; 824 random heights were generated from a normal distribution of height with mean 163 cm and standard deviation 6.1 cm. The bold face figures show the modal height groups. The last column gives the ratio (number of finalists/ number of women) in each height group. The frequencies in the tail ends of distribution are combined (lower tail 2/14 = 0.14; upper tail 80/3 = 26.7).

The ratio demonstrates that for each finalist in the modal height group of the general population there are 55.6 in its tallest height group (26.7/0.48 = 55.6).

Figure reproduced from Khosla and McBroom (1984).

CORRESPONDENCE

37 Upper Gordon Road,
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Surrey,
GU15 2ER

To the Editor:

Dear Sir,

MARATHON RUNNING AND MUSCLE FASCICULATION

A 55 year old male untypically failed to finish a marathon race because of excessive fatigue and muscle pain. That afternoon he was nauseated and developed for the first time coarse vigorous fasciculation of the calf muscles. One week later he re-ran the marathon and finished. Two days later he developed an upper respiratory infection. Now one year later he is well and continues to run but the fasciculation persists. The association of transient fasciculation with acute muscle fatigue is well recognised (Patten, 1977), but I have not found a reference to a chronic benign form. Imprudent distance running should be included in the differential diagnosis for muscle fasciculation of the lower limbs in this age group.

Yours faithfully,

A. M. W. PORTER

Reference

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