ROYAL INSTITUTION OF GREAT BRITAIN.

WEEKLY EVENING MEETING,

Friday, January 28, 1927.

J. MITCHELL BRUCE, C.V.O. M.D. F.R.C.P., Vice-President,
in the Chair.

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The Physique of Women Employed in Industry.

IN spite of the large amount of work which has been done on the anthropometry of man, but little attention has been given to the determination of the physical measurements of women. This is very clearly seen, for instance, if the classical report of the Anthropometric Committee of the British Association be examined. The insistance on the measurement of the male is perhaps even more strikingly demonstrated in the tabular matter of Baldwin's Physical Growth and School Progress Report. This shows that, although there is ample material available for males of all ages, and a fair amount of data for female children, there is a real deficiency of data concerning women. Miss Lucy Cripps in her report gives data for a number of women, but these are almost exclusively of the student class.

The question might well be asked, Of what moment is it that the information is not available? Quite apart from the fact that it would be a matter of some general interest to have a body of data on the physical condition of women available, this information would be almost certainly essential if any legislative action in the form of further welfare work on behalf of women, particularly with regard to protection from overloading, was contemplated. As a matter of fact the present inquiry was begun in response to a request from the Secretary of State for Home Affairs to the Medical Research Council for information which would guide him in laying down, if considered necessary, the optimum load to be carried by women and

female young persons in factories. I was requested by the Council to undertake the inquiry.

As regards the mode of attack it is obvious that there are, at least, two promising methods: one, to have a series of weighings of loads actually carried by women in factories; the other, to determine, by experimental means if possible, the optimum load. In a previous piece of research work undertaken in conjunction with Captains Richardson and Campbell for the Army Hygiene Advisory Committee on the optimum load to be carried by the soldier, we had found that the load could be stated in general terms as a percentage of the body weight. As it was not difficult to obtain the mean weight of the soldier, it was therefore easy to state the actual weight, which should not be exceeded, for the average soldier. The attempt to apply these methods to women shows up at once the poverty of physical data. Even although the actual loads were determined by a very large series of weighings, and although by experimental methods it could be shown that a load weighing so many pounds was the optimal load, if these values are to be converted into a form suitable for insertion in a parliamentary bill, the loads would require to be related, not to the limited number of individuals measured or to the few laboratory subjects, but to the average woman engaged in industrial work.

Obviously if we were to carry out the new investigation along the same lines as were employed in the Army investigations—and our previous results appeared to justify this course—we had to obtain anthropometric information about the women engaged in industrial work.

We accordingly attacked the problem along the following lines:—

1. The determination of the physical characters of the average women engaged in industry.
2. The determination in the laboratory of the optimal load.
3. The determination of loads actually carried in the course of ordinary work by women.

The Chief Inspector of Factories and the late Senior Medical Inspector of Factories detailed Dr. S. Overton, Woman Medical Inspector of Factories, to carry out a series of special measurements of loads actually carried in factories. Dr. Overton was also asked to obtain the body weight of the woman carrying the load at the time the measurement of her load was made. Dr. Overtou obtained information from 417 women and female young persons. Her report was of great practical value, giving details, as it did, of conditions within actual factories.

As regards our side of the work, Dr. Catherine Blair and Miss Enid Weatherhead, B.Sc., obtained a series of measurements from

3076 factory women drawn in samples from areas in Glasgow, Lancashire, the Midlands and London. In addition to the examination of the women actually engaged in active factory life, through the courtesy of the Ministry of Labour they were allowed access to the Labour Exchanges. They determined the physical condition of 413 women who had previously engaged in factory work, but who had been unemployed for a year or longer. Also in order to obtain a control group of another class, through the courtesy of the Director of the Glasgow Provincial College for the Training of Teachers, they were allowed to examine 460 of the women students.

Miss Elizabeth Bedale, M.A., and Dr. Katherine Macleod carried out the laboratory series of experiments in which the physiological cost, to the organism, of the carriage of the various loads was determined from the respiratory exchange.

As my time is limited I shall confine my remarks this evening to the determination of the physical standards of the women examined. We obtained in addition to certain other information, which will be found in the full report, the age, weight, height, lumbar pull, grip and crush of the various subjects. We selected the three strength tests mentioned because we considered they would give a fairly comprehensive picture of the general muscular strength of the subjects examined. The *lumbar pull* was carried out (Fig. 1A) by the subject fixing the special dynamometer to the ground by standing on a block of wood to which it was attached, and pulling on the handle which was adjusted specially to her height. As the machine was a self-registering one there was no need to keep up tension until the reading was made. This pull not only tested the muscles of the back and the legs, but also those of the shoulders. The *hand grip* was tested (Fig. 1B), using the Smedley type of hand dynamometer with adjustable hand grip. We found it most essential that the finger piece should be a variable one, as this allowed all subjects to exert their most favourable grip. The *crush*: in the performance of both pull and grip many of the subjects utilise groups of muscles which are much used for carrying out similar operations in the course of their day's work, and hence the values obtained might be expected to vary with occupation. We introduced the crush test in the belief that, as the muscles involved were not commonly used in a continuous manner in industrial processes, it would give a better and more uniform test of the general muscular capacity of a wide variety of subjects. In carrying out (Fig. 1C) this test the arms were raised to shoulder level and the dynamometer held between the hands, clear of the chest wall, and force exerted by pressing inwards with the palms of the two hands.

We attempted to get as wide a survey of the industrial world as possible, selecting trades both heavy and light. The following table gives a list of the factories visited:—

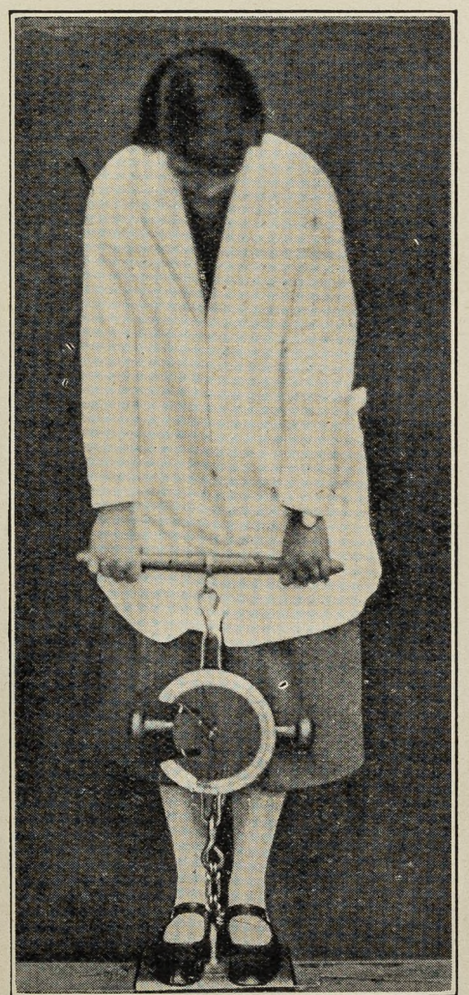
TABLE I.

Trade	District	Number of Firms
Printing	Glasgow	1
Engineering—		
Nut and Bolt Works	,,	1
Nut and Bolt Works	Midlands	1
Chain Works	,,	1
Hollow Ware Works	,,	1
Pen Works	,,	1
Telephone Works	,,	1
Textile	Glasgow	1
	Lancashire	2
Warehouse	Glasgow	2
Bakery	,,	1
Clothing	,,	1
Chemical	,,	1
Laundry	,,	1
	London	1
Shoes	Midlands	1
Pottery	,,	2
Bricks	,,	1
Confectionery	Glasgow	1
	London	2
Soap	,,	1
Bottling	,,	1

The heaviest work noted was that carried out in the chemical works (Glasgow) and the brick works (Midlands). Next to these industries come the nut and bolt, chain and hollow ware works, bottling, laundries, and some of the work done in the Potteries. As regards the remainder, except for a few operations, the work done was more or less sedentary. The work in many factories has degenerated into "machine minding," but although so much of it is now performed automatically, it must not be inferred that it has abolished skill. On the contrary it has only altered the type of skill. High-speed machinery in many occupations demands both manual skill and alertness of mind.

By far the most interesting works from our point of view were the two already referred to, as those in which the heaviest work was done, viz. the chemical works and the brick works. In the chemical works the girls employed were literally remarkable for their physique and the grace of their carriage. They all worked bare-footed and carried out their various operations with great skill and ease. The astonishing thing was that the majority of these perfect young women—no girl was employed under the age of 16—were born and bred in one of the worst districts in Glasgow. We were told that the mothers and grandmothers of many of the women

A



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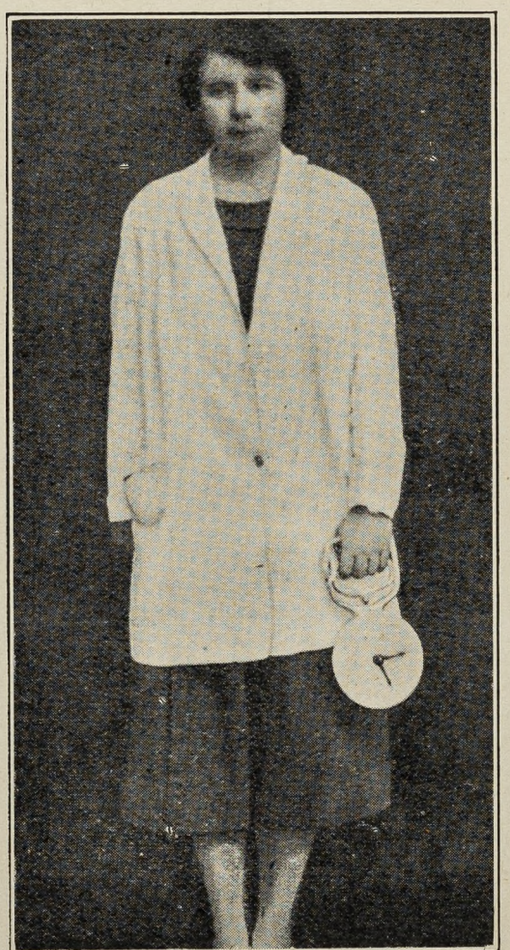

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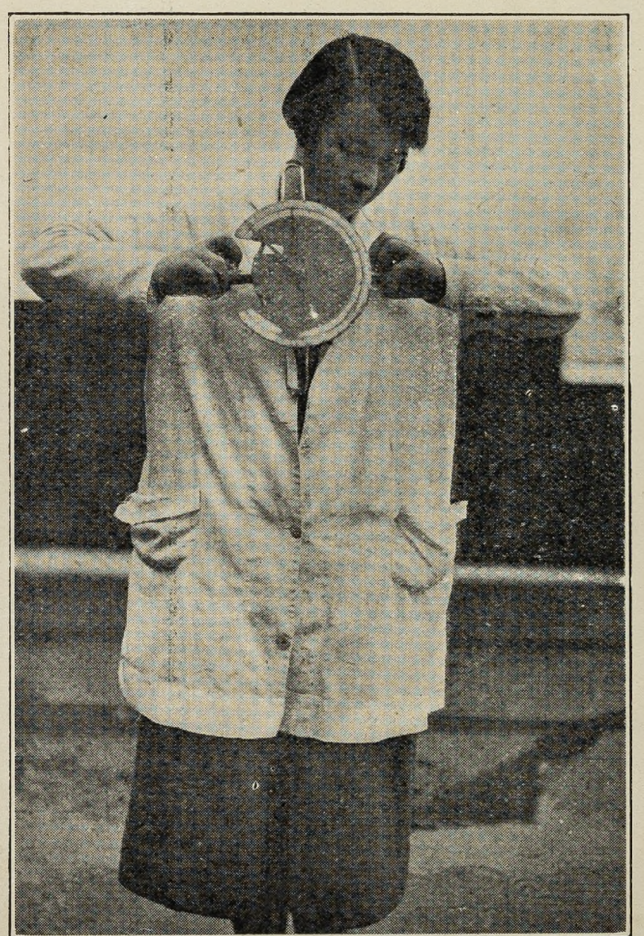

FIG. 1.

employed had done the same work before them. As evidence of what these workers could do we saw one woman who shovelled 20–25 tons of raw material, lifting it to a height of about 2·5 feet, per diem. Admittedly she was quite exceptional even in this works.

In the case of the brick works the work done was also very heavy. The girls carrying bricks, although they were permitted to select their own load, as a rule carried over 100 lbs. at a time for a distance of 70–80 yards, and the women, who conveyed their bricks in barrows, had normal loads of 4 to 4·5 cwts. Exceptionally heavy work is also at times done in brick works; thus, for instance, Dr. Overton in her report records that one woman in a brick works she inspected moved 36 tons of material in the course of the working day. Here again the good carriage of the women employed was noteworthy.

The following table gives a summary of the results obtained, with their standard deviations, classified in age groups:—

TABLE II.

Age. years	No.	Mean Weight. kilos.	S.D.	Mean Height. cms.	S.D.	Mean F.T.D. cms.	S.D.	Mean Pull. kilos.	S.D.	Mean Grip. kilos.	S.D.	Mean Crush. kilos.	S.D.
14	34	38·81	6·6	151·0	7·7	56·4	3·8	63·54	14·6	20·95	4·2	17·07	5·5
15	152	44·00	6·3	155·6	6·0	58·5	3·1	72·26	15·2	23·42	4·7	19·23	6·5
16	213	46·28	6·0	156·6	5·6	59·1	3·2	78·63	15·5	25·27	4·4	20·71	5·7
17	257	47·75	6·1	157·0	5·8	59·0	3·4	79·57	13·7	25·67	4·4	21·82	6·2
18	259	50·19	6·5	158·2	5·4	59·7	3·4	83·73	14·8	26·64	4·8	23·48	6·2
19	269	50·93	7·4	158·5	5·9	59·7	3·3	85·05	16·3	26·75	4·5	24·05	6·6
20	247	50·12	6·8	157·5	5·7	59·7	3·4	83·59	15·6	26·50	4·5	23·13	6·1
21	210	49·99	6·3	158·0	5·5	59·6	3·3	85·27	16·8	27·23	5·2	23·20	6·3
22	211	49·94	6·6	157·9	6·2	59·9	3·4	85·22	18·8	26·86	5·5	22·80	6·5
23	197	49·60	7·2	157·3	5·5	59·6	3·1	84·32	17·8	27·08	5·3	22·56	5·8
24	141	50·72	7·4	157·8	6·0	59·9	3·4	88·04	16·4	27·60	4·9	24·25	6·7
25	146	49·50	7·2	156·8	6·2	59·6	3·6	85·54	18·0	26·56	4·9	23·11	6·7
26	124	50·52	8·8	157·1	6·7	59·6	3·5	86·84	17·9	27·08	5·0	23·55	7·2
27–28	164	51·26	8·3	157·8	7·0	59·8	3·8	85·17	18·9	27·60	5·0	23·62	7·4
29–30	116	50·11	6·9	156·5	6·0	59·3	3·4	82·52	17·7	26·36	4·5	22·12	6·5
30–40	232	52·94	10·4	157·3	6·7	59·5	3·3	86·98	21·4	27·19	4·8	23·47	6·6
41–55	104	54·10	9·1	156·6	5·2	59·3	3·9	80·94	21·5	25·96	4·9	19·45	5·4

It is very obvious from the above table that nearly 50 per cent. of the workers examined by us are between the ages of seventeen and twenty-two. As our sample was a fairly large one we may assume that approximately the same percentage of women engaged in industrial work will be between the same ages. It may of course be argued that, as the individuals examined were all volunteers, the younger women would be more ready to undergo the test than the

older workers. Such a factor may indeed be operative, but in our opinion it cannot account for the large preponderance of young women comprised in the five years given. As a matter of fact we never had any trouble in any of the factories visited in getting a sufficient number of subjects. The nature of the test developed a spirit of competition. Fig. 2 shows very clearly the *percentage* age frequency of the employed and unemployed factory women.

As regards their body weight it will be noted that the weight rises fairly rapidly up to about the age of 18, and thereafter it remains reasonably constant until the third or fourth decades are reached. There is a definite rise in weight with the age group 30–40, and an even more marked, and not unexpected, rise in the following age group.

The height of the women examined seems to reach a level about the age of 17 or 18. It is interesting to note that after the first age group the height of the finger tips from the ground remains approximately constant (F.T.D., Table II.). This is a matter of some importance for the lay out of workshops. We took this measurement with the view of determining, if possible, the optimum height of the working bench. It would perhaps have been better, although more uncertain, to have taken the elbow height. The elbow height can be determined, however, from the finger tip distance, if there be added on the average length of forearm, as determined by Pearson and Lee. We found, using this addition, that the average elbow height of our series of workers came to 39·9 inches, a figure which agrees well with the American figure of 40 inches and that of Legros and Weston for 200 girls in this country of 39·5 inches. As the working place should be for comfort below elbow height—the arm inclined downwards at an angle of 15 to 20 degrees is comfortable, i.e. a drop of the fingers from elbow level of about 4 inches—it follows that the theoretical height of the average working bench should be about 36 inches high, and, if one to one and a half inches be allowed for the increased height of the worker due to shoe heels, the actual bench height should be about 37 inches.

As regards the strength tests it would seem from our figures that pull reaches its maximum about 18 years of age, as does also crush, whereas grip would seem to alter but little after the age of 16.

What then may be taken as the average values for women engaged in industry? The following table gives the mean values for all our subjects (3076) grouped together, and the same number separated into the official grouping of female young persons, Group I 14 to 16, Group II 16 to 18, and Group III women.

Or stated in English measure the average woman engaged in industry weighs approximately 109 lbs., is 62 inches tall, and has a pull of 183 lbs., a grip of 58 lbs. and a crush of 50 lbs.

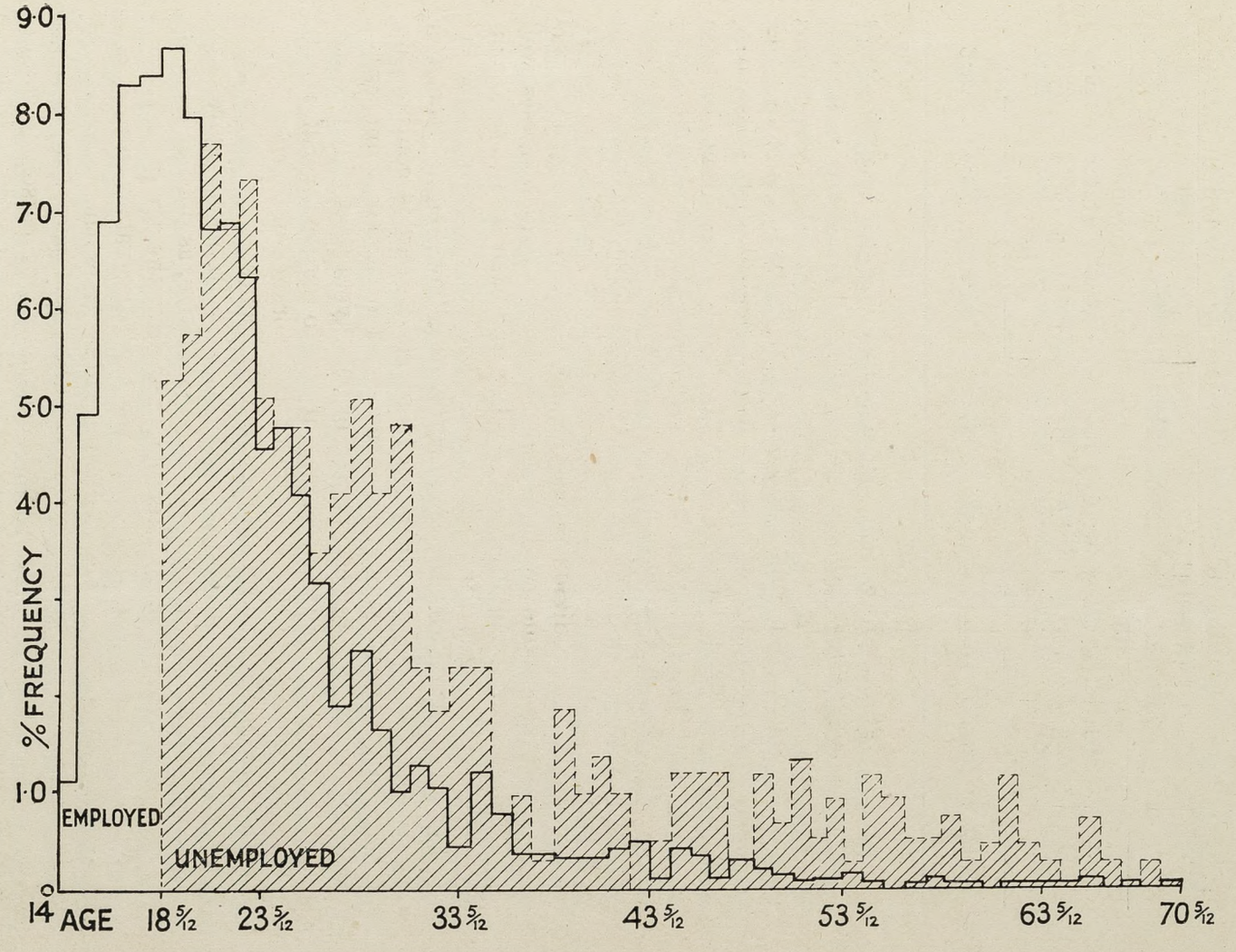

FIG. 2.—% AGE FREQUENCY OF EMPLOYED FACTORY AND UNEMPLOYED WOMEN.

TABLE III.

Group	No.	Percentage of Total	Mean				
			Weight	Height	Pull	Grip	Crush
I	399	12·97	44·76	155·8	74·9	24·2	19·8
II	516	16·78	49·00	157·6	81·7	26·2	22·6
III	2161	70·25	50·74	157·6	84·8	26·9	23·1
Total	3076	—	49·67	157·3	83·2	26·4	22·6

It was of interest to see whether any definite coefficients of correlation existed between the various physical characters measured. We found, as was to be expected, that there were high correlations between weight and height, about 0·5, and also between the various strength tests (pull and grip about 0·6, pull and crush about 0·5, and grip and crush about 0·47), but lower correlations between strength and height, about 0·35, and strength and weight, about 0·32. We found the correlation coefficients between weight and height and weight and the strength tests, as well as between height and the strength tests, to be all much higher in the first age group, of 14, than in any other. This particular group it may be remarked was small and highly selected, being for the most part girls in training in a weaving school attached to one of the factories. The fact that there is good correlation throughout between the various strength tests would seem to indicate, as might be expected, that there is, if the strength depends mainly on muscle development, a more or less uniform development of muscle in the different subjects, or, if the strength tests are indicative of more than mere muscle development (v.i.), that the factor operative is uniform for all types of muscle activity.

If we now turn to the consideration of the physical standards of the potential factory women, viz. those unemployed, some most interesting facts come to light. We obtained these women from the various Labour Exchanges in Glasgow, but found it somewhat difficult to get a sufficient number who had been engaged in factory work and who had been on the unemployed list for a year or more. Our primary object was to determine whether, when a worker had been unemployed for a year or more, there were any signs of physical deterioration. We examined 413 women between the ages of 19 and 55. The following table, in which the subjects, in order to get sufficient numbers for adequate statistical treatment, are classified in three age groups, gives the relevant data; below are given the data for appoximately the same age groups of employed women :—

TABLE IV.

Age	No.	Mean					Total Strength / Weight
		Weight	Height	Pull	Grip	Crush	
Unemployed.							
19–24	166	47·24	151·3	73·36	25·17	19·91	2·51
25–34	174	49·60	152·7	75·41	24·91	19·46	2·42
35–55	73	54·94	152·9	73·59	24·35	16·57	2·08
Employed.							
19–24	1275	50·22	157·9	84·63	26·16	23·32	2·67
25–30	550	50·38	157·1	85·09	26·94	23·15	2·68
41–55	104	54·10	156·6	80·94	25·97	19·45	2·34

And the averages for the total samples are as follows :—

TABLE V.

Group	No.	Mean									
		Weight	S.D.	Height	S.D.	Pull	S.D.	Grip	S.D.	Crush	S.D.
Employed	3076	49·67	7·7	157·3	7·4	83·18	17·6	26·44	4·9	22·60	6·5
Unemployed	413	49·60	8·8	152·2	6·8	75·07	17·8	24·91	4·9	19·13	5·7

It is then very evident, both from a comparison of the total sample and the groups classified into ages, that the unemployed women are of poorer physique than the employed. It is, however, of interest to note that taking the total sample comparison the two groups are of the same average weight, but that when the age classified groups are compared the unemployed women are found to be actually a few pounds lighter than the employed women of approximately the same age, But it will also be noted that the unemployed women, both in the total sample and in the age classified groups, are very definitely smaller in stature. It is possible then that the slightly lower weight of the unemployed is due, in the main, to their lesser height. That this is the case is shown if the weight/height ratio be taken. The values obtained are as follows :—

TABLE VI.

Weight/Height.

Age	Employed	Age	Unemployed
19–24	·32	19–24	·31
25–30	·32	25–34	·32
41–55	·35	35–55	·36

In spite of the comparatively low correlation, which was found to exist between weight and the various strength tests, it was thought that the ratio between weight and total strength might give some indication of the individual's general physique. The following table has accordingly been compiled (total strength is the sum of the three strength tests used) :—

TABLE VII.

Total Strength/Weight.

Age	Employed	Age	Unemployed
19–24	2·67	19–24	2·51
25–30	2·68	25–34	2·41
41–55	2·34	35–55	2·08

It is evident then that the ratio is smaller in the case of the unemployed. Here then we have to deal with unemployed women who, if weight is to be accepted as a criterion of nutrition, are quite as well nourished as their employed sisters, but who are both smaller and weaker. The suggestion is made that in many cases, where unemployment is prolonged, it is due to the fact that the woman's general appearance, her physique, has failed to appeal to those seeking labour. This view is supported, in our opinion, by the fact that, for instance, in one of the Exchanges with 2000 women on its lists, only about 140 of these had been out of work for over a year. The further fact that the strength of these women was below that of the employed women would almost certainly indicate that they were poorly developed rather than that they were weaker, solely because they were unemployed and their muscle flabby from lack of use. Most women have their homes to look after, and the ordinary household tasks of washing and scrubbing are much more strenuous occupations than the average industrial one, so their muscles at least are kept in reasonably good condition. Further, if there be, as is probable, a "mental" side to the exertion of strength, the poorer

strength records afford additional evidence in favour of the view that the unemployed were not, speaking generally, of the average quality of the employed women.

We can now turn to the consideration of what may be called our homogeneous control group, viz. the 460 students of the Glasgow Provincial College for the Trainiug of Teachers. This group of young women, although they lead an entirely different kind of life from the women engaged in industry, cannot be regarded as belonging to an affluent class. It is probably not overstating the matter to say that every girl in the college has of necessity to earn her own living. They are drawn from all parts of Scotland, although for the most part they belong to the West, and over 50 per cent. are country born and bred. The followlng table gives the results of our examination stated in four age groups : —

TABLE VIII.

Age	No.	Mean										Weight / Height	Total Strength / Weight
		Weight	S.D.	Height	S.D.	Pull	S.D.	Grip	S.D.	Crush	S.D.		
18	113	53·77	8·1	161·5	5·3	96·57	15·1	29·14	5·6	26·40	6·8	·333	2·83
19	139	52·78	7·3	160·7	5·4	96·09	16·3	27·61	5·0	26·38	7·3	·328	2·84
20	101	53·55	6·9	160·9	5·2	98·99	14·9	28·70	5·2	27·10	6·5	·333	2·89
21–22	107	52·00	7·3	160·8	5·0	100·63	15·3	28·67	5·2	26·91	6·8	·323	3·00

These young women then far exceed either of the other two groups in weight, height and strength. This is very plain when the table below giving the mean values for all three groups is examined :—

TABLE IX.

Group	No.	Mean Weight	Mean Height	Mean Pull	Mean Grip	Mean Crush
		kilos.	cms.	kilos.	kilos.	kilos.
Factory . .	3076	49·67	157·3	83·18	26·44	22·60
Unemployed .	413	49·60	152·2	75·07	24·91	19·13
College . .	460	53·01	161·0	97·90	28·47	26·66

The question of course arises whether these differences, which are found to exist, are merely the result of bad sampling, or whether they possess real significance. We accordingly worked out the probable error of the difference. If the difference found is three or more times the probable error of the difference it is regarded as being significant. When our values are considered in the light of

this they show quite conclusively that, apart from the slight difference found between the mean weights of the factory women and those unemployed, all the other differences may be considered as highly significant. (Figures represent the number of times the difference exceeds the probable error.)

TABLE X.

	Weight	Height	Pull	Grip	Crush
College and Factory Women . . .	13·4 : 1	28·0 : 1	28·3 : 1	11·3 : 1	17·6 : 1
College and Unemployed Women . . .	28·4 : 1	30·4 : 1	67·1 : 1	15·5 : 1	26·0 : 1
Factory and Unemployed Women . . .	0·23 : 1	21·5 : 1	12·9 : 1	9·0 : 1	16·5 : 1

Although the college girls undoubtedly take first place in these values, determined from the means, we found that if they were compared with a very selected body of industrial workers, like those in the chemical works already referred to, they no longer take the first place so far as strength is concerned, although they are still both taller and heavier. To what are we to ascribe this superiority of physique on the part of the college girls? Presumably their stature, and to a certain extent their weight, is to be related to their stock. But the observation that their strength is so much in excess of the average women engaged in factory work is of considerable interest. It is probably due, in large part, to the fact that in the college the girls are submitted to a thorough medical examination before acceptance, are well looked after and have to undergo, as part of their normal curriculum, a course in physical training. In addition to the admirable physical training the girls are encouraged to take exercise in the form of games, like hockey and tennis. But, it is also we believe in part due to the fact that strength is not merely a function of the amount of muscle present, but it is also related to mental alertness, so that when the subject is called upon to produce some effort she co-ordinates her powers better. Mosher and Martin, in their limited studies of American women, were also impressed with the fact that in the majority of instances the mentally more alert subjects were stronger than those subjects whose activities were habitually confined to manual labour.

One may naturally ask if it is possible to deduce any standard specification, which would be capable of general application, so that a worker may be classified in terms of fitness. We have attempted many forms of calculation, but, apart from the striking uniformity which is found to exist in the total strength/weight ratio, we have

obtained no very definite results. If the strength/weight ratio be taken as a criterion of physical fitness we find that the average value for the employed factory women is about 2·66, for the unemployed about 2·38, and for the college girls about 2·88. It may be hazardous to make a definite pronouncement, but, if our figures are of any value, then women with a fitness factor below 2·5 may be looked upon as probably unfitted for hard factory work, although still fitted for the lighter and less taxing occupations. Further, if the excellent physical condition of the college women is to be ascribed, as we definitely think it should, in part at least to the systematised physical training, our results should afford encouragement to those employers of labour who have included such exercises as part of their works' welfare schemes.

We have been able then in this investigation to get a good general idea of the type and the physique of the women engaged in industrial work in this country. Admittedly our sampling is limited, considering the number of women employed, and that it does not embrace the total industrial area of Britain; but, even so, our determination of the physical standards of the average industrial woman supplies data which hitherto have been lacking.

[E. P. C.]

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