RESEARCH BULLETIN 939 AUGUEST 1963

Energy Expenditures of Women Performing Household Tasks

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ACKNOWLEDGMENTS

The authors wish to express their appreciation to:

The Central Ohio Heart Association for grants made as partial support for the project.

The Hoover Company for the loan of vacuum cleaners Model Nos. 67, 88 and 2830, attachments for upright 6500.

Wilson Floors Company for the stair carpet.

Dr. C. R. Weaver for statistical analysis and guidance in design of project and interpretation.

Marjorie Keiser, research assistant in Home Economics at the time of study for help in collection of data on load carrying.

Women who cooperated as subjects.

The editorial committee of the project NC 9, Farmhouse requirements and their application in the improvement of farm housing.

8-63-3M

ENERGY EXPENDITURES OF WOMEN PERFORMING CERTAIN HOUSEHOLD TASKS

DORIS E. ELLIOT, MARY BROWN PATTON AND MARY EDNA SINGER

Changing conditions in the home are a factor in the apparent need for a better understanding of the various impacts of household work. More and more homemakers are pressured by dual occupations. Larger proportions of the population consist of older people, many with chronic disabilities, who desire to maintain their own homes. New equipment, improvements in the old and advances in space and working situations affect work methods, and, in turn, are affected by changing work methods.

Measurements of physiological and psychological costs of work might enable homemakers to weigh alternatives in making decisions involving time and energy.

The physiological cost of work of the home gains in significance from the sheer variety of body movements in which the homemaker is involved daily and often hourly. Stair climbing, bed making, carrying of loads, and even sitting and standing—all an integral part of the work of homemakers—involve reaching, stooping and bending.

Energy expenditure as measured indirectly by oxygen consumption is one of the physiological costs of work to be reported in this bulletin. Although the energy costs of some household tasks have been made by research workers in home economics, physiology and medicine, measurements of many activities are lacking.

For a long time home economics research workers at the Ohio Station have been interested in the relationship of energy expenditure and postural adjustments to methods of work, design of equipment, and space. As part of a North Central regional housing project*, a series of studies was planned to evaluate certain relationships. An annotated bibliography of the literature was prepared and distributed in mimeographed reports (18, 19). A manual has been published setting forth the step-wise procedures as used in this laboratory in the determination of energy expenditures of certain household tasks (5).

*Farmhouse requirements and their application in the improvement of farm housing.

BEDMAKING[1]

Bedmaking was chosen because it was believed that the economic situation and current building trends dictated bedrooms of such limited dimensions as to provide inadequate space and arrangement for bedmaking. In addition, a pilot study of space needs for bedmaking had been made at Illinois (another station in the North Central region) and measurements of energy exxpenditures would supplement this work.

The study of energy costs of bedmaking served as a pilot study primarily for testing the techniques that had been developed for use of the Kofranyi-Michaelis respirometer and the Beckman oxygen analyzer. Attention was also given to the relation of the cost of an activity expressed as gross Calories to Calories above basal and to Calories above standing.

The four subjects who participated in the bedmaking activity ranged in age from 23 to 32 years; in height from 61.5 to 68.0 inches and in weight from 116 to 144 pounds. The activities included making the bed by subject's own habitual method when the bed was adjusted at four heights, 20, 23, 26 and 30 inches; by two methods, the subject's own and a method established through a time and motion study (10), with the bed at two heights, 20 and 26 inches; in free and confined space by the standarized method with the bed at heights of 20 and 26 inches. The subjects performed each activity in quadruple. The heights of the bed in the four replications were arranged in a Latin square. The order in which the beds were made by the two methods was staggered on the four days.

The space in which the subjects worked was limited during certain phases of the study. Eight Plexiglas panels, 4′ × 6′ × 1/4″ (Figure 1) with holes drilled in the Plexiglas at intervals and the panels bolted together were used to form a room of the required dimensions. An opening was left at one end for a passageway. By placing supporting angles at the corners of the structure and allowing for overlap of the panels, there was sufficient rigidity for the panels to support their own weight in an upright position. The size of the room could be altered for subsequent tests by removing bolts from opposite sides, telescoping the panels to desired dimensions and placing bolts in aligned holes. Plexiglas was used so that motion pictures could be taken through it for use in another study dealing with posture (8).

[1]Data for this activity are taken from "Energy expenditure and its relationship to working heights, space, and methods of work in the performance of a household task". Unpublished Ph. D. Dissertation of Mary Edna Singer. The Ohio State University Library, Columbus.

Basal metabolic rates were observed by use of the Benedict-Roth apparatus. Energy expenditures during standing and making beds were determined by the Kofranyi-Michaelis respirometer. The expired air was analyzed for oxygen content using the Beckman analyzer. Techniques employed were those described in Research Circular 121.

The series of pictures, Figures 2, 3, 4, 5 and 6, shows some of the steps in making the bed by the Halbert method as reported by Mundel *et al.* (10). The Plexiglas panels used to simulate the walls of a room and the respirometer worn by the subject are shown in Figure 1.

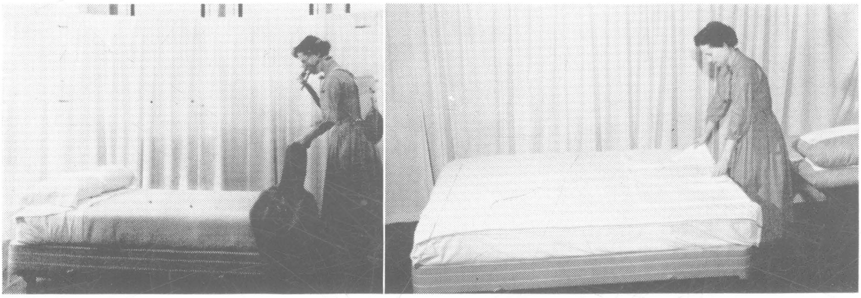
The data were analyzed statistically to determine the effects on energy expenditure of height of bed, method of making the bed and space allowances for the bedmaking activities.

The mean expenditure decreased from 15.853 to 14.361 total Calories and from 3.433 to 3.129 Calories per minute as the height of the bed increased from 20 to 30 inches. The difference between maximum and minimum time required for the four subjects to make the beds of the four heights was 1 minute 16 seconds and it can be said that bed height had no effect on time required. The differences in Calorie expenditures due to height of bed were significant.

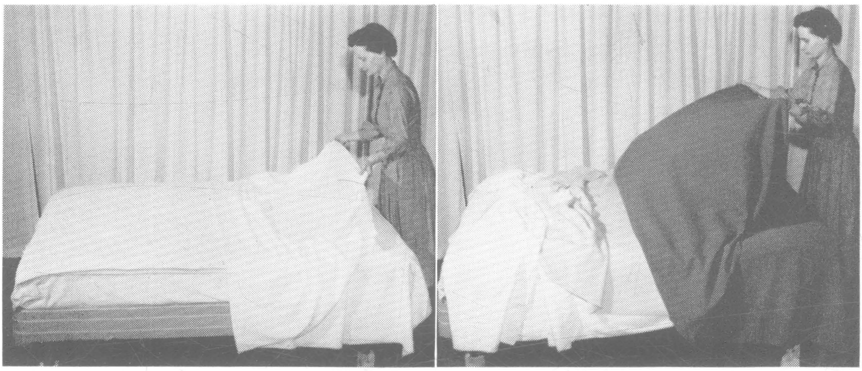
The mean expenditures varied from 14.025 to 15.206 total Calories when the bed was made by the two methods with the bed at 20- and 26-inch heights and in unconfined space; from 14.335 to 15.418 Calories with a 16-inch pathway around the bed; and from 14.249 to 16.777 Calories with the head and one side of the bed against adjoining walls and 24 inches at the foot and other side of bed. The differences in Calorie expenditures due to either space allotments or method of making bed were not significant.

Perhaps one of the more useful findings of the bed making study had to do with the relationship of gross Calories expended per minute for the activity to Calories above basal and above standing. These relationships for making beds at heights varying from 20 to 30 inches are shown in Figure 7. As can be noted in this figure the three lines are practically parallel denoting a consistent and proportional difference at the 4 heights studied. The data might also be interpreted to indicate that the basal and standing values are equally satisfactory as a base line for reporting Calorie expenditures.

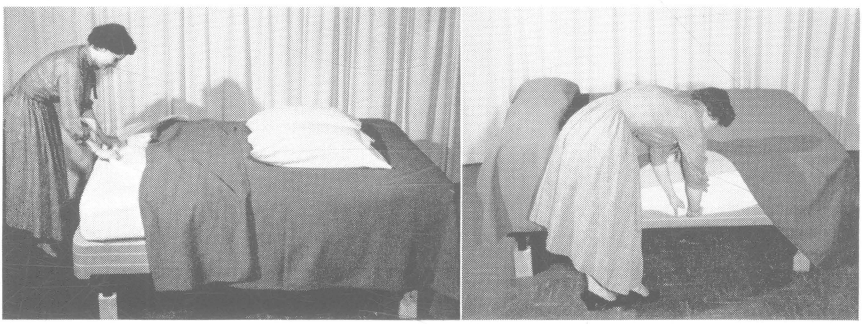
In general, basal metabolic rates of women vary within a comparatively narrow range from day to day within short periods of time, exclusive of menstrual periods. The data from this study would seem to justify the conclusion that daily basals are not necessary in a series of observations carried out within a comparatively short period of time. By omitting basals on certain days time can be saved. If standing



Figs. 1 and 2.—Subject at left is wearing respirometer while making a bed in confined space. Subject at right folds sheets widthwise with selvedges meeting at center of fold.



Figs. 3 and 4.—Unfolded sheets, left, are tossed toward head of bed. At right, bedspread is tossed toward head of bed.



Figs. 5 and 6.—Process is completed in one trip around bed to tuck in sheets, place pillows and smooth spread, left. Final step in bedmaking, right.

values do not vary with the time of day then the laboratory facilities can be used in both morning and afternoon.

The heights of beds used in this study were selected from those currently displayed ın furniture departments. They varied from those of the so-called oriental type to that of the hospital bed.

These limited data indicate the expenditure level in which bedmaking may be classed. Doctors and those workıng in the rehabilitation of heart patients as well as nutrition and home management specialists may find this information useful.

STAIR CLIMBING

Space allotments for stairs in small homes is often kept to a minimum to reduce costs and the pitch of the stairs has to be increased.

Observations were made of the energy expenditures of four young women ascending and descending stairs of three pitches without loads;

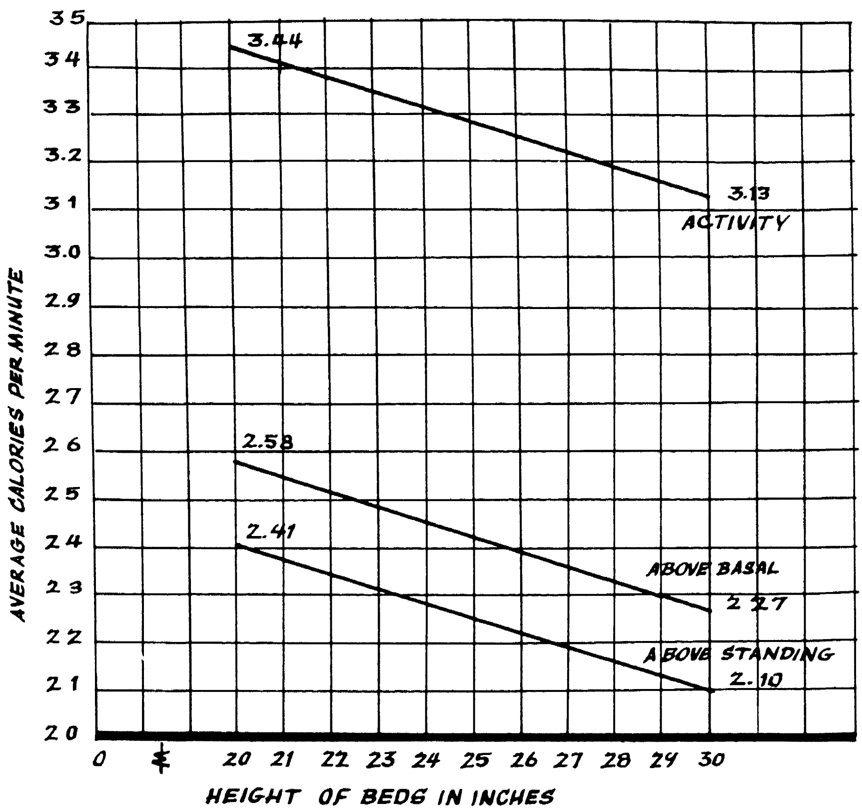


Fig. 7.—Regression of Calories per minute for activity, and above basal and standing.

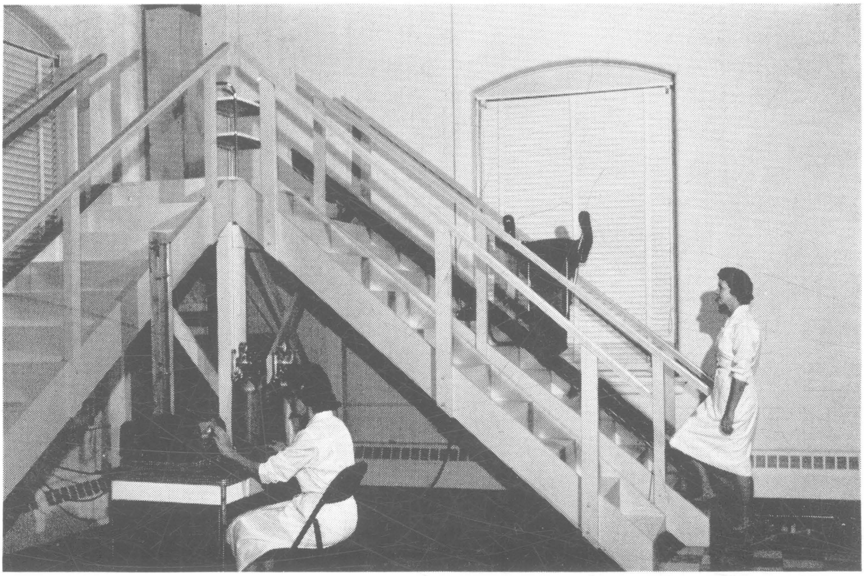


Fig. 8.—Arrangement of stairs in the laboratory.

10 young women ascending and descending one flight of stairs carrying 16-pound loads in three positions; 10 older women ascending and descending the same stairs carrying the same loads in the same manner as the younger women. The subjects climbed the stairs to the timing of a metronome (92 steps per minute).

The young women were between 26 and 36 years of age, 63.39 and 66.54 inches in height, and 117.0 and 149.0 pounds in weight. The older women were between 63 and 73 years of age, 61.32 and 66.14 inches in height, and 118.0 and 184.0 pounds in weight. The measurements of all subjects including their basal metabolic rates will be found in Tables 11 and 12 in the appendix.

The stairs represented those that might be found in the home; (a) basement stair, (b) first to second floor type, and (c) one suggested by architects where neither space nor cost present problems. The measurements of risers and treads were as follows:

Stair	Riser height inches	Tread width inches
a	9	11
b	7	9
c	7	11

The arrangement of the stairs in relation to each other in the laboratory may be noted in Figure 8.

No Loads

The four young women who served as subjects climbed one flight of stairs to the timing of a metronome, which required 8 seconds, then stood on the platform at the top of the stairs until a total of 5 minutes had expired. The subject rested for 5 minutes while sitting on a chair, and then descended another flight. The order for ascending and descending was planned so the subject would have to walk the least possible distance at the end of an ascent or descent to be in position for the subsequent activity. A desk chair with casters was used to move the subject from the bottom of one stairs to that of the stairs farthest away. At the top of all three stairs and at the bottom of the two parallel stairs, the subject had to walk only one or two steps in order to get into position.

The Calorie expenditures per minute of these four subjects are shown in Table 1. The description of certain characteristics of the subjects will be found in the appendix, Table 13. The cost of ascending was significantly greater than that of descending, averaging 1.561 and 1.336 Calories per minute respectively. Benedict and Parmenter (2) and Orsini and Passmore (11) presented data that confirms this general finding. The level of energy expenditure by the subjects in the present study was lower than that of subjects in the two studies cited above. At least some of the difference may be accounted for by procedures followed. In the present study the subjects rested while sitting on a chair and then climbed 13 steps in 8 seconds and the collection of expired air continued for 4 minutes and 52 seconds while the subjects stood quietly. In the Benedict and Parmenter study the subjects climbed 130 steps in a warm-up period and then energy expenditures were measured during a 2-minute climb. In the Orsini and Passmore

TABLE 1.—Energy Expenditures in Calories Per Minute of Young Women Climbing Stairs of Three Pitches (without loads).

Subject	Initial standing	Ascending stair I	Ascending stair II	Ascending stair III	Descending stair I	Descending stair II	Descending stair III
S.S.	1.246	1.503	1.597	1.580	1.346	1.365	1.319
J.D.	1.154	1.446	1.527	1.449	1.204	1.272	1.363
E.H.	1.260	1.661	1.669	1.750	1.452	1.383	1.433
J.B.	1.242	1.510	1.477	1.563	1.289	1.297	1.312
Average	1.226	1.530	1.568	1.586	1.323	1.329	1.357

study the subjects climbed 53 steps in 1 minute, were returned to the bottom by a lift and the ascent was repeated five times in this sequence. The collection of expired air continued for 5 minutes after the fifth replication with the subject in standing position.

The energy expenditure as reported for this study appears to be reasonable in relation to the expenditure for standing ($\bar{x} = 1.226$ Cal/min) particularly when one considers that the recovery period included 4 minutes and 52 seconds of standing. Ascending was 27 percent above standing, and descending 9 percent. Bratton (3) has pointed out that the time of ascent is probably under ¼ minute and total energy expenditure would be under 2 Calories (assuming the rate to be 7 or more Calories per minute). She goes on to say that "with the usual length of stairs in homes and with the normally spaced occurrence of the activity, the energy cost is not likely to be important for the healthy homemaker."

Because of the small sample of expired air collected in 8 seconds it would be impossible to determine the energy cost of the activity itself with the method used in this laboratory. It is possible that recovery from an activity of such short duration may be completed in less than the 4 minutes and 52 seconds allowed. Data collected on recovery during three 5-minute periods following other activities performed by women in this laboratory showed that recovery was complete at the end of 5 minutes. Taylor, MacLeod and Rose (17) suggest that .036 and .012 Cal/kg be allowed for ascending and descending, respectively, a staircase of 15 steps, without regard to time. This value is exclusive of basal metabolism and influence of food. In deciding upon a value for estimating energy expenditures of individuals in which stair climbing is involved it would be advisable to take under consideration the condition under which the subject will make the climb.

With Loads

Energy expended in carrying loads up and down stairs may be related to the position in which the load is carried. Studies were made of the energy expenditures of 10 young women carrying the following 16-pound loads up and down the stairs: a basket of clothes (Load I); an upright sweeper (Load II); and a doll (Load III). The doll was weighted with shot to make the loads equal in weight, *i.e.* 16 pounds. The position assumed in carrying each of these loads may be noted in Figures 9, 10, and 11. Pertinent data on these subjects may be found in the appendix. The Calorie expenditures per minute during load carrying are presented in Table 2.

Fig. 9.—Subject carrying basket of clothes (Load I).

Fig. 10.—Subject carrying upright sweeper (Load II).

Fig. 11.—Subject carrying doll (Load III).

TABLE 2.—Energy Expenditures in Calories per Minute of Ten Young Women Carrying Loads on a Stair.

Subject	Ascending Load I[1]	Ascending Load II[2]	Ascending Load III[3]	Descending Load I[1]	Descending Load II[2]	Descending Load III[3]
E.H.	1.348	1.290	1.101	1.236	1.358	1.220
G.C.	1.985	1.986	1.918	1.775	1.538	1.976
P.S.	1.630	1.705	1.708	1.725	1.210	1.276
J.R.	1.769	1.602	1.544	1.271	1.299	1.138
P.H.	1.720	1.622	1.586	1.846	1.559	1.600
J.H.	1.950	1.832	1.662	1.859	1.782	1.841
J.B.	1.245	1.149	1.276	1.680	1.591	1.549
R.C.	1.621	1.942	1.548	1.485	1.388	1.451
L.S.	1.661	1.741	1.606	1.545	1.373	1.364
S.O.	1.682	1.596	1.602	1.359	1.286	1.280
Average	1.661	1.646	1.555	1.578	1.438	1.470

[1]Load I: Basket of clothes carried in front.

[2]Load II: Vacuum sweeper carried at side.

[3]Load III: Doll carried over shoulder.

Analysis of variance (15) of the Calorie values indicates that there were no differences in expenditures due to type of load carried either while ascending or descending but there was a significant difference ($P = .05$) between expenditures while ascending and descending. The mean value of ascending was 1.621 Calories per minute as compared with 1.495 Calories while descending. The mean Calorie expenditure for standing prior to ascending was 1.019 and prior to descending 1.062. The increase for ascending was 60 percent above that for standing and for descending, 41 percent.

Orsini and Passmore (11) made a study of two subjects carrying loads of 15 and 30 kilograms (33.0 and 66 pounds) while ascending and descending a flight of 53 steps. The loads were carried on the back and suspended from the shoulder. The subjects climbed the stairs in 1 minute and were returned to the bottom by means of a lift (time, 1 minute). This was repeated five times and at the end the subject continued standing for 5 minutes. Thus, each experiment was of 15 minutes duration. Observations were also made of standing at ease and walking on the level. The results show that the cost of both ascending and descending increased with the increase in weight of load carried. The cost of ascending was greater than that of descending and in general the percentage difference increased as the weight of the load carried increased. The expenditure for climbing increased from approximately 480 Cal/hr (8.000 Cal/min) for no load to 850 Cal/hr (14.167 Cal/min) for the 30 kg load. The expenditure for descending varied from approximately 240 Cal/hr (4.000 Cal/min) for no load to 330 Cal/hr (5.500 Cal/min) for load of 30 kg. The values for standing with one exception were approximately 84 Cal/hr (1.400 Cal/min). These authors point out that the difference in costs of walking downstairs and walking horizontally is undoubtly spent in maintaining body posture in between the steps. They state, "We do not fall simply from step to step."

The difference in energy expenditure by the two subjects of Orsini and Passmore and the 10 Ohio women may be related to length of time activity was performed and differences in weights of loads carried. Although Orsini and Passmore did not state the sex of the two subjects it is assumed they were males.

In 1924 Bedale (1) made a study of one woman (height, 176 cm; weight with clothes, 56 kg; surface area $1.66m^2$) who carried varying weight loads in eight positions. She walked on the level a distance of 100 yards in 73 seconds, a rate of 2.8 miles per hour. With one exception, the observations were made in the morning, 2 to 3 hours after a light meal. Three 2½ minute-samples of expired air were taken at 20, 40 and 57 minutes of work. The loads carried weighed 20, 30, 40, 50 and in two cases 60 pounds. They were carried in front of the body, at the sides in either hand, on left shoulder, on left hip, on back, and on the head. When the load was carried on the shoulder, the weight was distributed over a board on the left shoulder in one case and in another it was divided between two pails and carried on a yoke. Minimal energy was expended when the loads were in pails suspended from a shoulder yoke, and maximal, when carried in a tray on the left hip. In the present study carrying the doll over the shoulder required slightly less energy than carrying the basket at the front and sweeper at the side but as stated earlier, the differences in energy expenditures were not significant.

The energy expenditures for carrying weights of 4, 6, 8, 10 and 12 pounds on the back or attached to the feet were reported by Draper *et al.* (4). The data showed that the energy expenditure for carrying a pound of weight attached to the feet was twice that for the same weight carried on the back. These latter two studies seem to indicate that the position in which a load is carried may be related to energy expenditures.

Another group of 10 Ohio women, aged 63 to 73 years, was observed while performing the same activity as the 10 young women. Five of this second group were less than 20 percent above their suggested weight for height and the other five were more than 20 percent above. The Calorie expenditures per minute are presented in Table 3.

The women who were less than 20 percent above suggested weight for height spent less energy than those over 20 percent. The difference was not statistically significant although the F value approached significance. The subject to subject variation was high (and the number of subjects in each group small) and this may have obscured the difference due to weight. When the data were calculated to Cal/min/kg and analyzed the difference in energy expenditure of the two weight groups was not significant.

Loads and direction (ascending and descending) were both significant factors in Calorie expenditure but there was no interaction. The mean expenditures for ascending and descending in Calories per minute were:

No load	1.532
Basket	1.776
Vacuum	1.718
Doll	1.631

Significantly more Calories were expended in ascending and decending with loads than without. The energy expenditure to carry

TABLE 3.—Energy Expenditures in Calories Per Minute of Ten Older Women Carrying Loads on a Stair.

Subject	Ascending Load I[1]	Ascending Load II[2]	Ascending Load III[3]	Descending Load I[1]	Descending Load II[2]	Descending Load III[3]
	Women less than 20% above suggested weight for height					
A.B.	1.793	1.736	1.578	1.486	1.486	1.382
E.K.	1.640	1.468	1.510	1.356	1.342	1.261
N.K.	1.958	1.920	1.850	1.546	1.516	1.475
C.B.	1.564	1.433	1.534	1.276	1.196	1.110
H.K.	2.012	1.798	1.736	1.977	1.736	1.664
Average	1.793	1.671	1.642	1.528	1.455	1.378
	Women more than 20% above suggested weight for height					
M.K.	2.340	2.270	2.295	2.206	2.110	2.045
A.E.	1.950	2.082	2.049	1.796	1.766	1.606
R.P.	1.894	1.936	1.806	1.591	1.476	1.490
E.M.	1.814	1.896	1.777	1.525	1.493	1.328
R.B.	1.950	2.009	1.758	1.854	1.686	1.364
Average	1.990	2.039	1.937	1.794	1.706	1.567
Average of both groups	1.892	1.855	1.789	1.661	1.581	1.472

[1]Load I: Basket of clothes carried in front.

[2]Load II: Vacuum sweeper carried at side.

[3]Load III: Doll carried on shoulder.

the doll was significantly less than for carrying either the basket or the vacuum ($P = .01$). The difference between the cost of carrying the basket and sweeper approached significance, .058 Cal, $L.S.D_{05}$ equals .059.

The mean cost of ascending, with and without loads, 1.797 Calories per minute, was significantly greater than that of descending, 1.532 ($P < .01$) with and without loads.

Analysis of variance (15) of the energy costs of stair climbing with loads by the two age groups indicated that the older women required more Calories than the younger women to ascend the stairs irrespective of loads. Figure 12 shows the energy expended by each group. The difference in Calorie expenditure between the two groups is less for the descent than for the ascent. In fact, there was no difference between the two groups in descending while carrying the doll (Figure 13).

The mean weight of the younger women was 130.04 pounds and that of the older women, 147.80 pounds. Five of the older women had a mean weight of 161.30 pounds and the other five, 134.30 pounds. Passmore *et al.* (12) reported on the energy expenditures of five male students 19-25 years of age while going up and down stairs at the rate of 97 steps per minute. Their weights varied from 131 to 183 pounds and the expenditures increased from 6.6 Cal/min for the 131-pound subject to 9.8 Cal/min for the 166-pound and then leveled off for the heavier subjects. The values reported are for the round trip and the authors did not comment on relative cost of climbing and descending.

McKee *et al.* (9) studied the energy expenditures of 25 normal and 19 obese persons. They report that the increasing energy expenditure for obese persons was due entirely to the increase in basal expenditure. Among the 10 older women reported in this bulletin the 5 who were more than 20 percent above suggested weight had a mean basal rate of 0.940 Cal/min as compared with 0.842 for the 5 women less than 20 percent above their suggested weight. As stated earlier the difference between the Calorie expenditure of the two groups while carrying loads was not significant but F values approached significance. The difference in basal rate may have been a factor.

CLEANING STAIRS

The studies of climbing stairs with and without loads were followed by observations of the cost of cleaning stairs covered with hard surface (vinyl treads) and soft materials (carpet). In order to evaluate the difference between energy expenditures due to type of covering the same general work methods and the same four tools were used on both. In addition, a fifth tool, different for each covering but appropriate for the covering, was employed. The stairway used consisted of 12 steps with 7-inch risers and 11-inch treads, such as first to second floor stairs found in homes.

Method

The carpet used was Wilton all wool, full pitch, placed on a 40 ounce felt pad. It was 27 inches in width and covered all but 3 inches of the width of treads and risers.

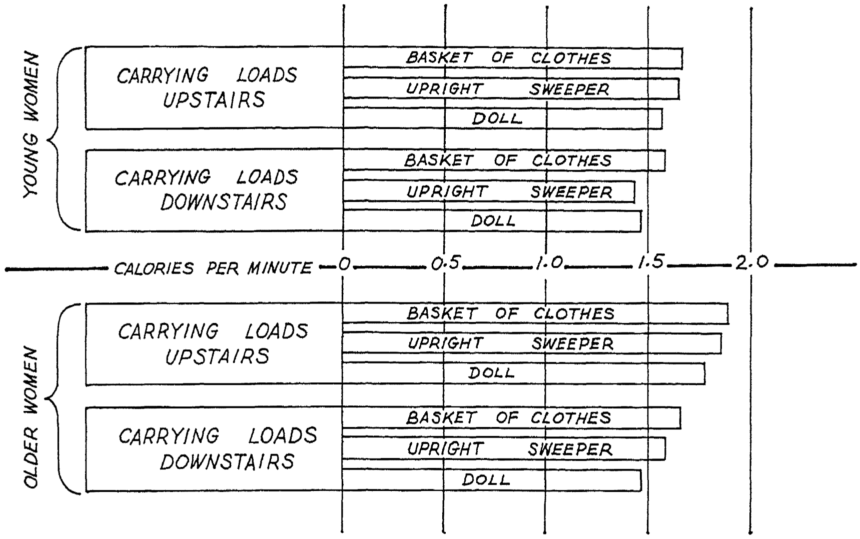


Fig. 12.—Average energy expenditures of women carrying three loads on stairs.

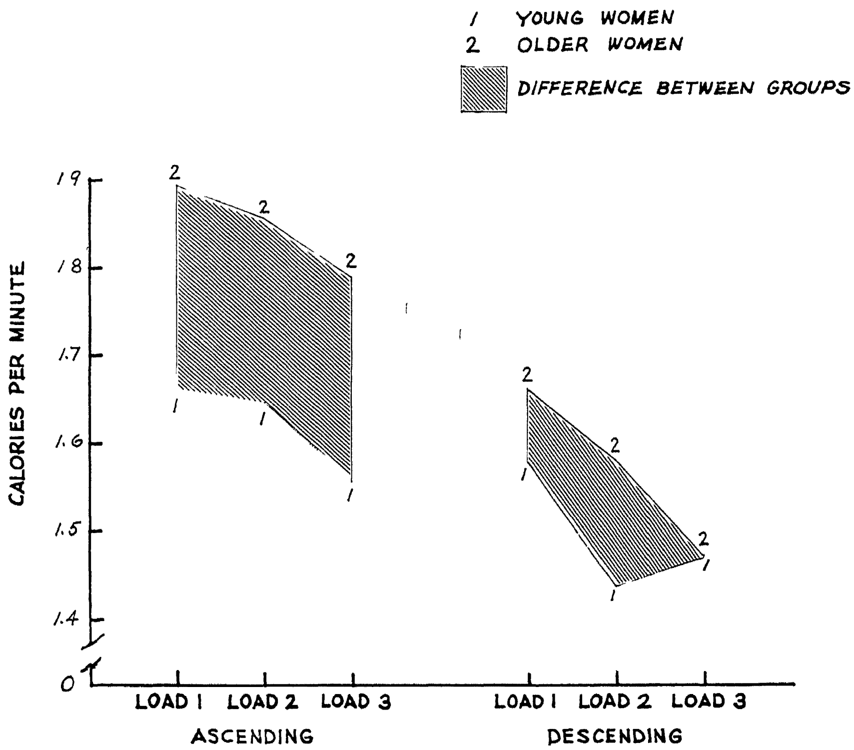


Fig. 13.—Comparison of energy expenditures between young and older women carrying loads.

The vinyl treads, 12″ × 18″, were centered and tacked to each step. Approximately 2 inches of the width of the tread was used for covering the nosing of the step and was tacked to the top of the riser of the step below. The treads (except for nosing) contained ridges running horizontally. A 6-inch space on either side of the tread was not covered.

Tools used in cleaning both types of coverings were:

(a) whisk broom and dust pan
(b) special purpose cleaner
(c) tank cleaner
(d) upright cleaner with attachments

In addition, carpeted stairs were cleaned (treads only) with an upright cleaner and stairs with vinyl treads were washed with a terry cloth and water.

Ten subjects participated in the cleaning of stairs with each of these coverings. Description of certain characteristics of the two groups are found in Tables 14 and 15 in the appendix.

In order to determine the amount and type of soil commonly found on stairs permission was obtained from 10 homemakers to collect soil on their stairs using the tools that were to be used in the study. In the homes of five of these women second floor carpeted stairways were cleaned; in the homes of the remaining five, basement stairs with a hard surface tread cover were cleaned.

Each stairway was cleaned once and the soil collected from each was weighted, sifted to separate into "fuzz" and grit, and the component parts weighed. The average weight of each lot was 15 grams grit and 3 grams "fuzz". These amounts were distributed routinely on the laboratory stairs preceding each stair cleaning test except when the vinyl treads were washed with a terry cloth. Additional amounts of soil were collected until a sufficient amount was obtained for the entire study.

Instructions were formulated for cleaning the stairs taking into consideration the tool used and the stair covering. The general directions included such items as timing for ascending the stairs to begin work, location of tools, designation of starting point and direction of motions. The subjects were asked to ascend the stairs at the rate of 92 steps per minute to the timing of a metronome. The stairs consisted of 12 steps and 13 risers and work was started on the left hand side of the first riser and proceeded to the right. Cleaning of the first tread began on the right and preceded to the left. This pattern was followed for all risers and treads. In cleaning the carpeted stairs with the upright cleaner only the treads were cleaned but the directions of the motions were the same, that is, from left to right, right to left.

When the thirteenth riser had been cleaned the subjects were instructed to place tools in a specified position and stand at rest at the foot of the stairs.

Instructions for cleaning with power driven tools with attachments were similar. The positions of the subject and the tool on the stairs varied with the eqiupment used. The special purpose cleaner was supported on the right of the body at the waist by a strap placed over the left shoulder. The subject ascended nine steps and began work. The tank cleaner was carried up to the fifth step, the subject ascended four more steps and began work. She cleaned five risers and treads, picked up the tank and carried it to the foot of the stairs, returned to the fifth step and continued cleaning. The upright cleaner with attachments was carried to the platform at the top of the stairs, the subject descended three steps (ninth step of stairs) and began work. Upon completion of cleaning of the third tread, she ascended, picked up the equipment and carried it to the foot of the stairs. She ascended to the sixth step and continued cleaning.

The subject turned the switch to "on" and "off" as required. At the completion of cleaning she propped the equipment held in her hands (the wand) against the wall and stood in place. The special purpose cleaner was removed by a research worker as quickly as possible after the subject had completed the task.

To clean the riser the nozzle was placed against the riser and moved upward. This stroke was repeated with a slight overlap until the riser was cleaned. The number of strokes varied with the tool used due to the variation in width of nozzles. For the special purpose cleaner seven strokes were used; for the tank type, four strokes; and for the upright with attachments, five strokes. To clean the tread the nozzle was placed at the junction of riser and tread moved forward to the nosing. The same number of strokes was used for the tread as had been used for the riser and varied with the tool used as indicated above. In cleaning treads with the upright only three strokes were used.

In using the hand tools, dust pan and whisk broom, the procedure was varied in order to collect the soil on each step. The riser was cleaned in a horizontal direction without collection of soil and the tread, with collection of each stroke of the whisk broom from back to front. At the conclusion of cleaning the tools were placed on the bottom step.

In washing the stair with vinyl treads the subject ascended ten steps and set the pail of water on this step. The riser was cleaned by wiping across using a circular hand motion. The tread was cleaned by wiping across in a horizontal direction. The cloth was rinsed and excess water wrung out and the procedure repeated. The pail was moved each time a step was descended.

Rate of work was not controlled and as a result the time spent in completing a task varied among subjects.

Results

The data for energy expenditures when using the four tools common to stairs with both coverings were analyzed by analysis of variance to determine differences in energy expended when using the various tools.

Carpeted Stairs

The energy expenditures in Calories per minute of each subject for each tool are given in Table 4. Considering the five tools used in cleaning carpeted stairs it may be noted from Figure 14 that the energy cost per minute was greatest when the upright without attachments was used. Although only the treads were cleaned the subject was required to lift the tool (18 pounds) from step to step and in moving across the tread as well. To manipulate this tool in working on a stair required a certain rigidity of the body not required in the use of the other power driven tools with the wand. Of the remaining four tools, the use of the upright with attachments required the greatest expenditure. The sweeper was carried both up and down the length of the stairs because the hose was not long enough to clean all steps with the tool in one position. Its greater weight (21¼ pounds as compared with the special purpose with wand and brush, 6¾ pounds, and the tank with wand and large floor brush, 19 pounds) may account partially for the increased expenditure over those of the other power driven tools. The energy cost was least when the special purpose cleaner was used. The fact that fewer steps were taken, the cleaner weighed less and the weight was supported from the shoulders may be factors in the reduction in energy expenditure.

The energy expended in using the hand tools, whisk broom and dust pan, was greater than that expended by using the motor driven ones with the exception of the upright with attachments. The subject stood upright with only a slight body bend when using the power driven tools but the body bend increased considerably when the hand tools were used. Ray (13) observed that women spent more energy in cleaning floors on hands and knees than when cleaning with tools (hand and motor driven) when the women stood upright.

TABLE 4.—Energy Expenditures in Calories Per Minute of Ten Subjects While Cleaning Carpeted Stairs with Five Tools.

Subject	Tools used				
	Whisk broom A	Special purpose B	Tank C	Upright & attachment D	Upright E
L.S.	3.718	2.844	3.150	2.741	2.845
E.H.	1.507	2.459	2.906	3.232	3.351
L.G.	2.941	2.657	3.887	3.585	3.004
D.P.	3.360	2.595	2.695	3.255	3.699
J.B.	3.319	2.523	2.582	3.216	3.047
D.R.	3.230	2.710	3.049	3.521	3.596
H.C.	3.631	3.204	3.065	3.387	3.525
J.D.	3.293	3.403	3.366	3.612	3.467
B.G.	3.465	3.263	3.524	3.625	3.783
B.K.	3.209	2.009	2.678	2.553	2.936
Average	3.167	2.767	3.090	3.273	3.325

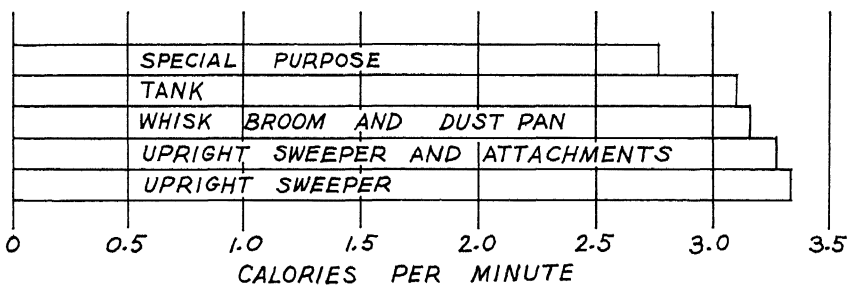


Fig. 14.—Average energy expenditures of women cleaning a carpeted stair using different tools.

The time spent by each subject in cleaning the carpeted stairs with each tool is shown in Table 5. The least mean time was spent in cleaning with the upright. As has been already stated, only the treads were cleaned with this tool and only three strokes were used which may explain in part the shorter time used. The mean time was greatest when cleaning with the special purpose machine. This type had a smaller nozzle and required seven strokes to clean each tread and riser, as compared with four for the tank and five for the upright with attachments.

The amount of time spent by one subject exceeded that spent by one other by 100 percent or more for all tools except the special purpose. In other words, one subject worked at least twice as fast as one other in the group when using each of four of the five tools.

TABLE 5.—Time Spent in Cleaning Carpeted Stairs with Five Tools.

Subject	Tools used: Whisk broom A		Special purpose B		Tank C		Upright & attachment D		Upright* E	
	min	sec	min	sec	min	sec	min	sec	min	sec
L.S.	5	58	6	49	6	49	9	13	5	5
E.H.	4	35	8	34	6	55	7	50	3	3
L.G.	7	2	6	48	7	30	8	3	3	41
D.P.	5	36	6	21	5	3	5	58	2	32
J.B.	5	15	8	27	6	55	7	8	3	13
D.R.	8	16	6	7	4	4	4	51	2	7
H.C.	8	48	7	45	8	58	8	57	4	3
J.D.	4	17	5	6	4	57	5	31	2	55
B.G.	2	40	4	55	4	2	4	25	2.	40
B.K.	6	26	9	22	5	58	6	43	4	30
Average	5	53	7	1	6	7	6	52	3	23

*Treads only were cleaned with this tool.

TABLE 6.—Energy Expenditures in Calories Per Job for Ten Subjects Using Five Tools on Carpeted Stairs.

	Tools Used				
Subject	Whisk broom A	Special purpose B	Tank C	Upright & attachment D	Upright E
L.S.	22.196	19.396	21.483	25.272	14.453
E.H.	6.902	21.074	20.110	25.307	10.221
L.G.	20.675	18.068	29.152	28.859	11.055
D.P.	18.816	16.478	13.610	19.432	9.358
J.B.	17.425	21.319	17.867	22.930	9.811
D.R.	26.712	16.585	12.409	17.077	7.624
H.C.	31.953	24.831	27.493	30.314	14.276
J.D.	14.094	17.355	16.662	19.938	10.124
B.G.	9.252	16.054	14.202	16.022	10.101
B.K.	20.634	18.824	15.988	17.156	13.212
Average	18.866	18.998	18.898	22.231	11.024

Mean time spent was compared with mean Calories per minute expended. Cleaning with the upright required the greatest energy expenditure per minute and the least time. Cleaning with the special purpose tool required the least energy expenditure per minute and the greatest amount of time.

The mean Calories expended per job (Table 6) ranged from 11.024 for the upright to 22.231 for the upright with attachments. The expenditures per job for the other three tools were 18.866, 18.898 and 18.998 Calories for the whisk broom, tank and special purpose respectively.

It is probable that most homemakers would make it a practice to clean the risers periodically although they might not clean them as frequently as the treads. The contrast in energy expended per job for the upright and the other tools may not be as great as these figures seem to indicate when all factors involved are considered. In fact, the upright (without attachments) would appear to be more suitable for cleaning floors than stairs because of the difficulty of handling it on the stairs. Swartz (16) reported that the total energy cost of cleaning rugs with the upright increases with increased speed. The cost at ½ foot per second was 55.5 Cal/hr/m^2 and 146.3 Calories at 4 feet per second.

The efficiency of cleaning with the different tools was not evaluated. It is generally agreed that a standard vacuum cleaner is more efficient than the small type. The upright with the revolving brush and agitator, the model used in this study, had certain advantages over the straight suction type.

Vinyl Treads on Stairs

The energy costs in Calories per minute of cleaning the stairs with vinyl treads are shown in Table 7. The mean Calories expended were greatest when the stairs were cleaned with water and a cloth and the least when the special purpose cleaner was used (Figure 15). The other three mean expenditures came within a comparatively narrow range, 3.532 (whisk broom), 3.430 (upright with attachments) and 3.152 Calories (tank). When the tools used required the subject to make greater body bends the energy expenditures were greater. As pointed out earlier Ray (13) made a similar observation among subjects using different tools in caring for kitchen floors.

The time spent by each subject in cleaning the stairs with each of the five tools is shown in Table 8. The greatest mean amount of time was spent in cleaning with the special purpose cleaner and the least with the whisk broom and dust pan. As with carpeted stairs, the spread in time spent between the slowest and the fastest worker was approximately 100 percent, that is, one woman worked twice as fast as another in doing the same job. Comparison was made between mean time and mean energy cost. The least energy spent per minute and the greatest mean time were associated with cleaning with the special purpose cleaner. The greatest mean energy expenditure was spent when cleaning with water and a cloth and this activity ranked third in amount of time used doing the job.

The energy expenditures per job were calcuated for each subject when using each tool by multiplying energy expenditure per minute by time spent in doing the job. These values are presented in Table 9. The costs of cleaning with the whisk broom and the special purpose cleaner would appear to vary more from subject to subject than those with the tank and upright with attachments.

TABLE 7.—Energy Expenditures in Calories Per Minute of Ten Subjects While Cleaning Stairs with Vinyl Treads.

Subject	Tools used: Whisk broom A	Special purpose B	Tank C	Upright & attachment D	Cloth & water M
J.B.	2.951	2.794	2.907	2.126	3.676
D.P.	3.697	3.312	3.478	3.814	4.555
E.H.	4.136	3.328	3.423	3.711	4.633
L.S.	3.680	2.867	2.925	3.836	4.804
J.D.	3.678	2.768	3.119	3.345	4.055
S.S.	3.469	2.666	3.204	3.549	4.105
D.R.	3.076	2.349	2.553	3.504	3.923
B.G.	3.304	2.702	3.910	3.864	4.006
P.H.	3.100	2.078	2.656	2.867	3.429
W.C.	4.230	2.841	3.348	3.684	5.021
Average	3.532	2.770	3.152	3.430	4.221

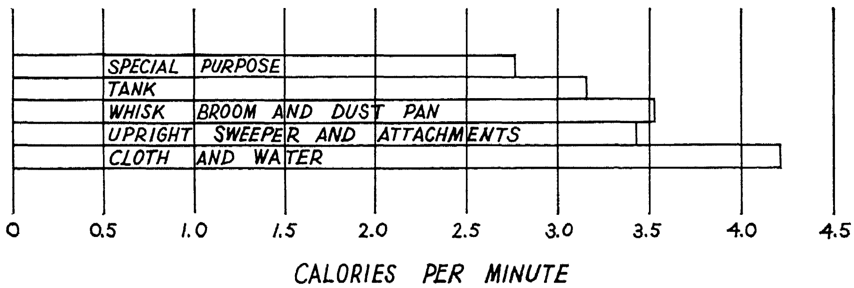


Fig. 15.—Average energy expenditures of women cleaning a stair using different tools. Vinyl.

TABLE 8.—Time Spent in Cleaning Stairs with Vinyl Treads with Five Tools.

Subject	Tools used: Whisk broom A		Special purpose B		Tank C		Upright & attachment D		Cloth & water M	
	min	sec	min	sec	min	sec	min	sec	min	sec
J.B.	2	45	3	41	5	22	7	29	4	20
D.P.	5	43	5	11	4	9	5	5	5	25
E.H.	5	22	5	52	5	18	5	52	5	42
L.S.	5	30	6	52	5	30	5	9	4	13
J.D.	5	20	4	31	4	25	4	29	4	3
S.S.	4	24	7	17	5	25	5	23	6	7
D.R.	2	27	9	26	6	22	4	59	5	3
B.G.	2	19	3	40	3	7	3	49	5	49
P.H.	3	16	5	32	4	8	5	0	3	2
W.C.	7	57	5	11	3	31	4	2	5	22
Average	4	30	5	43	4	44	5	8	4	55

Carpet Versus Vinyl Treads

An analysis of variance (15) of the data on cleaning stairs with the four tools used on both types of covering indicated that (a) there was no significant difference in energy expenditures between cleaning carpeted stairs and those with vinyl treads; (b) there was significant differences in expenditures due to tool used; and (c) the tool differences were constant regardless of floor cover.

It is probable that the average homemaker would not own all three types of power driven cleaners used in this study. If she has only one, usually she selects the one best suited to her needs in terms of type of covering on the largest area to be cleaned. Many houses today are built on the one-floor plan and may or may not have a stairs. If they do, it would be a basement stairs and would most likely have either no special covering or a hard surface.

TABLE 9.—Energy Expenditures in Calories Per Job for Ten Subjects Using Five Tools on Stairs with Vinyl Tread.

	Tools used				
Subject	Whisk broom A	Special purpose B	Tank C	Upright & attachment D	Cloth & water M
J.B.	8.115	10.282	15.552	15.902	15.917
D.P.	21.147	17.156	14.434	19.375	24.688
E.H.	22.210	19.535	18.142	21.784	26.408
L.S.	20.240	19.696	16.088	19.755	20.273
J.D.	19.604	12.511	13.786	14.986	16.423
S.S.	15.264	19.408	17.366	19.094	25.123
D.R.	7.536	22.151	16.263	17.450	19.811
B.G.	7.665	9.916	12.199	14.760	23.315
F.H.	10.137	11.491	10.969	14.335	10.390
W.C.	33.628	14.716	11.785	14.847	26.963
Average	16.555	15.686	14.658	17.229	20.931

These data may be useful in deciding between use of hand tools and motor driven ones in cleaning stairs when energy expenditures need to be kept at a minimum.

In other cases these data may be useful in deciding between satisfaction in the cleaning results and energy costs with the different tools.

OBSERVATIONS OF FACTORS RELATED TO ENERGY EXPENDITURES

As this series of studies progressed an effort was made to gain as much information as possible on factors related to energy expenditures. Among these factors were: (a) length of recovery period; (b) effect of a standardized meal; and (c) rate of work.

In the study of bed making the partial method of determining energy expenditure was used. The subject experienced a warm-up period to attain a physiological steady state. Then the volumes of expired air were measured during the activity. In the case of stair climbing and load carrying the integral method was used. The subject rested in a sitting position, and then collection was made for 5 minutes including the activity. Continuation of collection following the activity allows for any oxygen debt that might have been incurred during the activity. Five minutes was chosen because it was anticipated that recovery would not extend beyond this time. The tasks to be studied were of short duration and are generally classed as light to moderate activities. Insull (6) suggests a period of 5 to 10 minutes for recovery.

In the study of stair cleaning activities the integral method was modified to measure the extent of the oxygen debt. The subject rested for 5 minutes in a sitting position. The energy expenditure of standing during three 5-minute periods was determined following this rest period and a mean of these observations was calculated. The energy cost of the activity was measured, followed by the measurement of three 5-minute periods while the subject stood quietly. Then the subject rested for 5 minutes in a sitting position followed by the performance of another activity in which the procedure of collection of expired air was the same as described above.

The data from the studies of cleaning carpeted and vinyl covered stairs were analyzed to determine the length of recovery period. Comparisons of energy expenditure during the activity and total, which would include oxygen debt, were then calculated. In measuring the energy expenditure of an activity of a duration of less than a minute (such as climbing one flight of household stairs which required only 8 seconds in the case of the study in this laboratory) the above method is not applicable. The aliquot of expired air for this short period was not sufficient for analysis of oxygen.

The expenditure values of several activities performed during a single morning following the measurements of cost of standing were used as an evaluation of the effect of the specific dynamic action of the standard breakfast eaten preceding all activities.

The results of the observations on factors related to energy expenditures are now presented. Mean expenditure during initial standing and the expenditures for each of the three periods following an activity were plotted and these observations were made. It was obvious that the expenditure (a) during the first 5 minutes following an activity was greater than that for the subsequent 5-minute intervals and (b) that of the initial standing value was similar to those of the second and third periods following the activity. Figure 16 is an example. Analysis of variance indicated that the Calories per minute expended during the first 5-minute period following an activity were significantly higher than those expended in the second and third periods. Furthermore

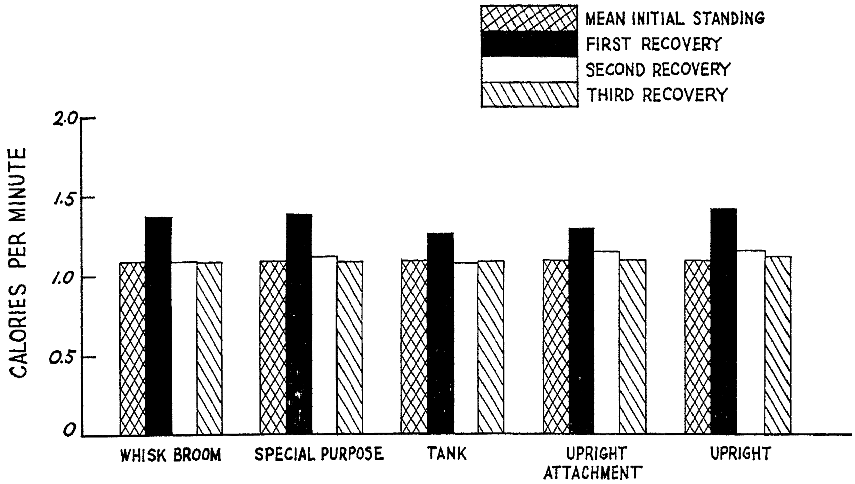


Fig. 16.—Energy expenditure of a subject during initial standing and recoveries following cleaning of carpeted stairs with each of five tools.

an analysis showed that the mean Calorie expenditure of standing (before the activities) and that of the second and third periods following the activities did not differ significantly. These analyses would indicate that the difference between the expenditure of initial standing and that of the first 5-minute period following represents oxygen debt. This amount added to the expenditure determined for the duration of the activity represents the total cost. Data for 20 subjects for four activities showed that the oxygen debt was from 6.61 to 10.32 percent (mean 8.23) of the Calories expended during the activity. The expenditures of these activities were in the range of 3 to 4 Calories per minute. Expenditures during the activity and total (including oxygen debt) are given in Table 10.

The Calories expended during standing for the initial period and those during the second and third periods following an activity were plotted in order of time performed regardless of activity in order to evaluate the effect of a standardized meal. There was no consistent pattern in an increase of expenditures in successive periods. Figure 17 shows the group average expenditures. The statistical analysis showed the difference to be nonsignificant.

Elliot and Patton (5) point out that no effort was made to control the rate at which the women worked. In the stair cleaning activities the subjects were asked to complete the job using a prescribed method-

TABLE 10.—Energy Expended in Calories per Minute in Cleaning Stairs During Work Period and Total Including Oxygen Debt.

Subject	Whisk broom		Special purpose		Tank		Upright & Attachment	
	Work period	Total	Work period	Total	Work period	Total	Work period	Total
	Calories per minute carpeted stairs							
L.S.	3.718	4.326	2.844	3.165	3.150	3.527	2.741	2.884
E.H.	1.507	1.678	2.459	2.598	2.906	3.121	3.232	3.365
L.G.	2.941	3.134	2.657	2.856	3.887	4.474	3.585	3.958
D.P.	3.360	3.739	2.595	2.878	2.695	2.945	3.255	3.597
J.B.	3.319	3.641	2.523	2.640	2.582	2.716	3.216	3.216
D.R.	3.230	3.585	2.710	2.986	3.049	3.324	3.521	3.912
H.C.	3.631	3.916	3.204	3.505	3.065	3.237	3.387	3.594
J.D.	3.293	3.533	3.403	3.625	3.366	3.580	3.612	3.957
B.G.	3.465	3.969	3.263	3.500	3.524	3.836	3.625	4.174
B.K.	3.209	3.443	2.009	2.009	2.678	2.678	2.553	2.553
Average	3.167	3.496	2.767	2.976	3.090	3.344	3.273	3.521
	Calories per minute stairs with vinyl treads							
J.B.	2.951	3.305	2.794	3.014	2.907	3.093	2.126	2.923
D.P.	3.697	4.079	3.312	3.576	3.478	3.762	3.814	4.195
E.H.	4.136	4.462	3.328	3.462	3.423	3.802	3.711	3.878
L.S.	3.680	3.968	2.867	3.116	2.925	3.096	3.836	4.089
J.D.	3.678	4.045	2.768	2.851	3.119	3.316	3.345	3.532
S.S.	3.469	3.833	2.666	2.953	3.204	3.446	3.549	3.610
D.R.	3.076	3.151	2.349	2.457	2.553	2.553	3.504	3.631
B.G.	3.304	3.743	2.702	2.981	3.910	4.374	3.864	4.177
P.H.	3.100	3.520	2.078	2.237	2.656	2.821	2.867	3.148
W.C.	4.230	4.699	2.841	3.098	3.348	3.437	3.684	3.841
Average	3.532	3.880	2.770	2.974	3.152	3.370	3.430	3.702

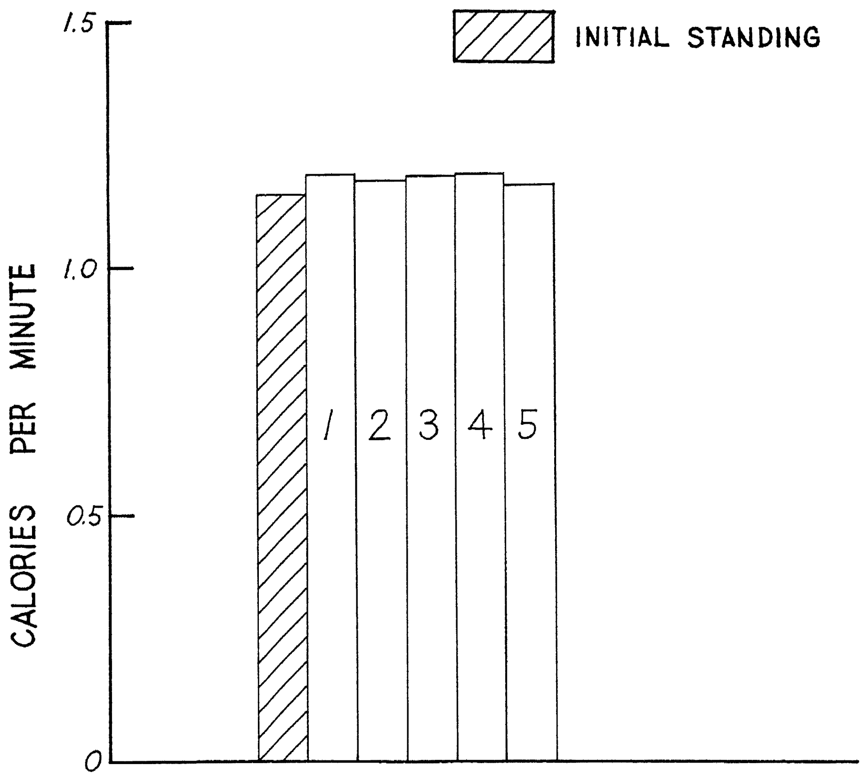


Fig. 17.—Expenditure in calories per minute of initial standing and the mean of second and third recovery periods following each activity in order of performance (1-5) during a laboratory period.

ology such as number of strokes, working from left to right and right to left without regard to the time required. Figure 18 shows the Calories per minute expended by 10 subjects during the cleaning of carpeted stairs with a whisk broom and dust pan during each of three 5-minute periods following the activity. They are arranged in order of expenditures from greatest to least. The time spent in performing the the activity in minutes and seconds is inserted on the column representing the expenditure during the activity. It may be noted that there appeared to be no relationship between rate of work and Calorie expenditure. Recovery for subject B. G. who spent the least time (2 min. 40 sec.) did not appear to be attained at the end of 5 minutes, at least to the degree that it was for the other subjects. She completed the

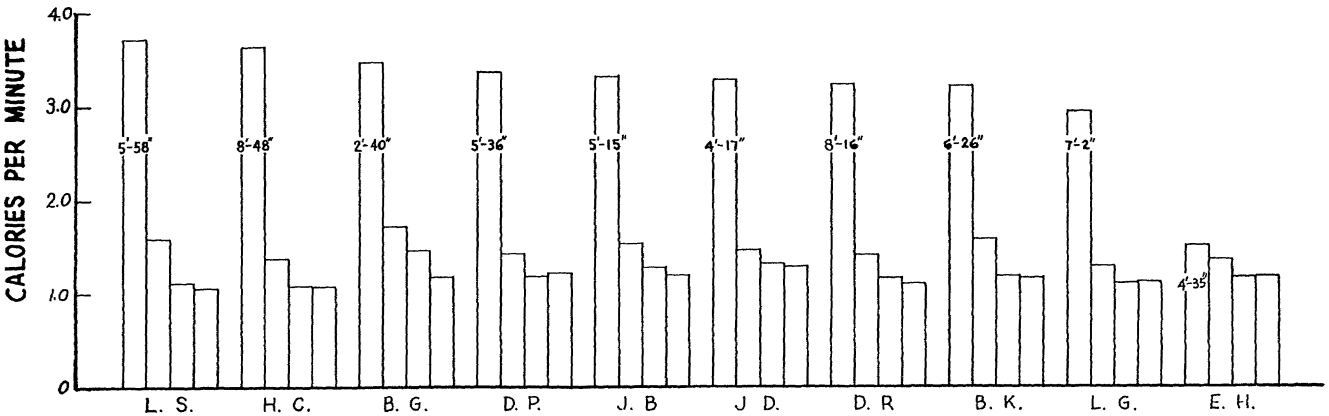


Fig. 18.—Energy expenditure in calories per minute during work period and three 5-minute recovery periods for 10 women cleaning a carpeted stair. The figures in the first bar for each subject represent time spent.

cleaning tasks with five tools in less time in four out of five cases than any other subject. In two of the five cases she used the most energy; in two cases, second highest and in the fifth case (whisk broom and dust pan), third highest. In the latter case, if cost of recovery was added to that of the activity for B. G. as well as the other subjects she would have been second highest. In only the one case, following the use of the whisk broom and dust pan, did recovery for B. G. appear to continue beyond the first 5-minute period although Calories expended during an activity were greater in three other cases. More information is needed on rate of work and time spent in an activity or activities in relation to energy expenditures. In the average household, the homemaker moves from one activity to another without intervening rest periods. The practice of multiplying time spent in various activities by the average Calorie requirement of each of these activities may need to be re-evaluated.

Average values are often used in making recommendations concerning activities of individuals with physiological limitations. Perhaps one of the more common restrictions is that of stair climbing imposed upon patients with heart impairments. The average energy expenditure of stair climbing obtained in this study would place either ascending or descending a household stairs in the class of light to moderate activity. These values apply to the conditions of this study in which the subject made a single ascent or descent of an average household stair preceded by a rest while sitting.

Karpovich (7) states, "If exercise is moderate and uniform, the oxygen intake rises gradually and then, in a minute or two, levels off and remains at this level for the duration of the exercise . . . During this state, the oxygen intake is equal to the oxygen expenditure."

During these series of studies observations were made of energy expenditures during standing in the morning following breakfast and in the afternoon following lunch. Five subjects were observed at both periods and the mean expenditure in the morning was 1.112 Calories compared with 1.229 in the afternoon. Variations among subjects would appear to be greater than that between morning and afternoon.

The observations made on factors related to energy expenditures have given indications of possible answers to questions that arise from time to time in studies of energy expended in household tasks.

SUMMARY

Energy expenditures of women performing certain household tasks were observed under laboratory conditions. The activities were: bed making; stair climbing with and without loads; and cleaning of stairs covered with hard surface and soft materials. In addition, certain observations were made dealing with factors related to energy expenditures.

A detailed report of the procedures used in estimating energy expenditure by the indirect method of calorimetry has been presented in Research Circular 121.

Four subjects made beds adjusted at heights of 20, 23, 26 and 30 inches; by two methods with bed at heights of 20 and 26 inches; and in free and confined space with bed at heights of 20 and 26 inches. The data indicate that (a) the height of the bed was inversely related to energy expended; (b) method of making the bed and energy expenditure were not related; (c) space allotments and energy cost were not related.

Four subjects climbed three sets of stairs corresponding in pitch to those that might be found in homes, including a basement stair, a first to second floor type, and one suggested by architects where neither space nor cost presents a problem.

The average energy cost of ascending was significantly greater than that of descending, 1.561 and 1.336 Cal/min respectively. The analysis of variance indicated that the energy expended in climbing the stairs of the three pitches did not differ significantly.

A group of ten young women (26 to 36 years of age) each carried a basket of clothes, an upright sweeper, and a doll, each weighing 16 pounds up and down stairs. There were no significant differences in expenditure due to load. The mean expenditure of ascending was 1.621 Cal/min as compared with 1.495 Calories while descending and the difference was significant at the 5 percent level. The increase in expenditure for ascending was 60 percent above that of standing and for descending, 41 percent.

Another group of 10 women (63 to 73 years of age) was observed while carrying the same loads as the younger women. Five of the older women were less than 20 percent above their suggested weight for height and the other five were more than 20 percent above. The heavier women spent more energy than the lighter weight women; the difference while not significant at .05 was significant at .16. When data were calculated to Cal/kg and analyzed the difference in energy expended by the two weight groups was not significant. Loads and

direction (ascending and descending) were both significant factors in Calorie expenditure but there was no interaction of these two factors. Mean Calories per minute were 1.532 for no load; 1.776 for basket of clothes; 1.718 for upright sweeper; 1.631 for doll (L. S. D_{05} =.059). The mean cost of ascending, 1.797 Cal/min was significantly greater than that of descending, 1.532 ($P < .01$).

The older women required more Calories than the young women to ascend the stairs irrespective of loads. The difference in Calorie expenditure between the two age groups was less for the descent than the ascent. There was no difference between the expenditures of the two groups in descending while carrying the doll.

Ten women cleaned stairs covered with a soft material (carpet) and with a hard surface material (vinyl treads) using five tools. Four of the five were used on both coverings. A fifth tool, different for each covering, but appropriate for the covering was used. The four tools consisted of three motor driven cleaners, *i.e.* a special purpose, a tank and an upright, and the fourth a whisk broom and dust pan. Analysis of variance of the energy expended in cleaning the stairs indicated that there was a significant difference in energy expended due to tool use. The expenditures using the upright with attachments were 3.273 and 3.430 Cal/min when cleaning stairs with carpet and vinyl treads; using the special purpose cleaner, 2.767 and 2.770 Calories per minute respectively. The difference due to covering was not significant.

The energy expended in cleaning both types of coverings with hand tools was greater than that expended in using the motor driven tools with the exception of the upright with attachments on carpeted stairs.

Time spent in cleaning both types of coverings and with the four tools by one subject exceeded that spent by one other by 100 percent or more.

An effort was made during these studies to measure, directly or indirectly, the effects of certain variables that may account in part for differences in expenditures reported by various workers. Those studied were length of recovery period, effect of a standardized meal and rate of work.

Recovery from oxygen debt was attained within 5 minutes and amounted to approximately 8 percent of the Calories expended during the task.

Calories expended during standing at intervals during 3 to 4 hours following breakfast were compared to measure the effect of eating. There was no consistent pattern (increase or decrease) in expenditure in successive periods and the differences were not significant.

Calories per minute expended by the 10 women in cleaning the stairs with a whisk broom were arranged in order of expenditures from greatest to least. When time spent in performance of the task was associated with the expenditure there appeared to be no relationship between rate of work and Calorie expenditure.

RECOMMENDATIONS

In the estimation of energy expenditures of household tasks consideration should be given to the conditions under which the homemaker will perform these tasks. The values reported in this bulletin are based on observations for tasks performed as an entity without relation either to other tasks performed during the day or for the same tasks performed more than once.

In the average household the homemaker either goes immediately from one task to another or performs the same activity several times or for longer periods of time than were the cases in these studies. The present method of adding expenditures for individual tasks may not give a true value of the energy cost of performing the day's tasks.

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APPENDIX

TABLE 11.—Pertinent Data for Ten Young Women Who Carried Loads on Stairs.

Subject	Height Inches	Weight Pound	Age Years	Basal metabolic rate* Cal/min
E.H.	64.17	140.50	31	0.950
G.C.	64.96	149.00	34	0.930
P.S.	66.54	132.25	27	0.895
J.R.	65.35	117.00	31	0.952
P.H.	65.35	125.00	26	0.881
J.H.	66.14	125.00	27	0.988
J.B.	63.39	130.50	32	0.936
R.C.	63.78	125.00	34	0.811
L.S.	63.78	137.12	36	0.862
S.O.	63.78	119.00	28	0.827
Average	64.72	130.04	31	0.903

*Determined on Benedict-Roth apparatus.

TABLE 12.—Pertinent Data for Ten Older Women Who Carried Loads on Stairs.

Subject	Height Inches	Weight Pound	Age Years	Basal metabolic rate* Cal/min
A.B.	61.42	118.00	66	0.775
E.K.	64.57	128.00	64	0.740
M.K.	63.58	184.00	73	1.129
N.R.	66.14	144.00	65	0.954
A.E.	63.38	182.00	64	0.944
R.P.	61.32	136.50	67	0.828
E.M.	63.38	144.50	67	0.856
C.B.	61.42	124.00	63	0.786
R.B.	62.99	159.50	64	0.942
H.K.	64.96	157.50	68	0.954
Average	63.32	147.80	66	0.891

*Determined on Benedict-Roth apparatus.

TABLE 13.—Pertinent Data for Young Women Who Climbed Stairs.

Subject	Height Inches	Weight Pound	Age Years	Basal metabolic rate* Cal/min	Average standing Cal/min
S.S.	65.20	130.08	25	0.927	1.246
J.D.	65.16	136.16	30	0.895	1.154
E.H.	63.90	145.95	33	0.801	1.260
J.B.	63.82	126.33	34	0.910	1.242
Average	64.52	134.63	30	0.883	1.226

*Determined on Benedict-Roth apparatus.

TABLE 14.—Pertinent Data for Ten Subjects Who Cleaned Carpeted Stairs

Subject	Height Inches	Weight Pound	Age Years	Basal metabolic rate* Cal/min	Average standing Cal/min
L.S.	63.43	135.08	37	0.818	0.991
E.H.	63.90	143.77	33	0.997	1.184
L.G.	66.93	130.30	27	0.872	1.105
D.P.	64.57	140.77	37	0.904	1.060
J.B.	63.82	133.95	33	0.900	1.218
D.R.	63.50	131.14	39	0.914	1.052
H.C.	63.46	120.27	40	0.861	1.088
J.D.	65.16	135.27	30	0.895	1.231
B.G.	66.69	140.83	27	0.864	1.204
B.K.	67.32	129.33	27	0.992	1.346
Average	64.88	134.07	33	0.902	1.148

*Determined on Benedict-Roth apparatus.

TABLE 15.—Pertinent Data for Ten Subjects Who Cleaned Stairs with Vinyl Treads.

Subject	Height Inches	Weight Pound	Age Years	Basal metabolic rate* Cal/min	Average standing Cal/min
J.B.	63.50	131.89	34	0.910	1.230
D.P.	64.09	143.58	38	0.843	1.308
E.H.	63.90	134.20	34	0.798	1.288
L.S.	63.58	135.58	38	0.831	1.326
J.D.	65.35	130.77	30	0.894	1.326
S.S.	65.87	127.70	26	0.888	1.317
D.R.	67.13	143.39	32	0.854	1.381
B.G.	66.26	131.52	28	0.870	1.254
P.H.	65.16	129.58	29	0.825	1.153
W.C.	62.80	137.95	37	0.968	1.204
Average	64.76	134.62	33	0.868	1.279

*Determined on Benedict-Roth apparatus.