

Energy Expenditures of Homemakers Performing Floor-Care Activities and an Evaluation of Floor Appearance

JOHNNIE RAY HOOPES

MARY BROWN PATTON

OHIO
AGRICULTURAL
EXPERIMENT
STATION

WOOSTER, OHIO



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JOHNNIE RAY HOOPES AND MARY BROWN PATTON*

INTRODUCTION

The increased use of smooth-surface floor materials throughout the house makes information concerning their care of importance to many homemakers. This study was carried out to help meet the need for an increased understanding of the use of selected methods, materials, and equipment for effective floor care.

The interaction of methods and tools in the care of floors prompts their consideration as a unit. The limited availability of small tools for a given task which complement the physical characteristics of the worker may be indicative of the little concern held for these floor-care tasks. Modifications of either the tools or their use are frequently necessary for performance of these activities with ease.

It is generally recognized that a protective wax layer enhances floor appearance and that waxed floors withstand wear and require less care than unwaxed ones. By shortening time devoted to household tasks, homemakers release time for other interests.

Women have accepted liberation by machines from a number of household tasks; similarly, the acceptance of machines for household floor maintenance may be expected to follow the same pattern. Determining energy costs of persons when performing floor-care activities is one approach to appraising the efficiency of methods and tools. Energy and time costs of performing tasks by various methods can be used in developing more efficient procedures.

Objectives of the present study were (1) to determine energy expenditures, blood pressures, and heart rates of women when performing floor-care activities on waxed and unwaxed floors; (2) to obtain an energy expenditure basis for selecting tools and methods for performing floor-care tasks; (3) to evaluate the appearance of floors and to obtain reactions of participants to prescribed floor-care practices during an experimental period.

*This study was reported in detail in a Ph.D. dissertation (Ray, Johnnie Nell. 1962. Energy expenditures of women performing household floor-care activities, The Ohio State University).

PROCEDURE

Twenty-five homemakers living in north Columbus, Ohio, followed prescribed practices and recorded time spent in kitchen floor-care activities for a 6-month period. For six of the 25 women, energy costs, blood pressures, and heart rates when performing floor-care activities were obtained under controlled conditions in the laboratory. By using energy costs from the laboratory and time reported by homemakers, calculations of energy expenditures were made as estimates for performing the same tasks in homes.

In the laboratory the six homemakers performed the same task with several different tools in order to obtain information on energy expenditures as a basis for selection of tools commonly used in floor care activities.

Limitations of time and number of subjects made it impossible to have the homemakers use all these tools in the home. Criteria for selection of those to be used in the home were developed and will be discussed.

PRELIMINARY PLANNING

Subjects. Homemakers were selected on the basis of age, presence of children under 18 years at home, and characteristics of kitchen floor. Women were to be between 25 and 50 years old. Consideration was given to height and weight of women under 40 years of age as six laboratory participants were to be chosen from this group. Flooring material was to be permanently installed, less than 20 years old with surface in good condition, and either inlaid linoleum, vinyl asbestos, or vinyl.

The six homemakers selected for laboratory participation ranged in age from 26 through 37 years, in height from 63 through 67 inches, and in weight from 127 through 144 pounds. Basal metabolism determinations were made in advance and at the end of the laboratory period. The lower or lowest basal metabolism values for each subject are given along with height and weight in Table 1.

Laboratory kitchen area. To carry out floor-care activities in the laboratory it was necessary to have an area which would simulate a home kitchen (Fig. 1). The plan which was used provided 9.74 square yards of available floor space (Fig. 2). Four sets of movable floors were constructed of $\frac{3}{4}$ inch plywood covered with vinyl sheet material. For ease of handling, each set consisted of four panels.

The factory finish on the floors was removed to simulate wear by using a scrubbing pad on a professional-size floor machine with a mild abrasive and wax remover and cleaner.

TABLE 1.—Age, Height, Weight, and Basal Metabolism of Laboratory Subjects.

Subject	Age ^a	Height ^b	Weight ^c		Basal heat production		Deviation from standard ^d	
			Initial	Final	Initial	Final	Initial	Final
	yr	in	lb	lb	Cal/m ² /hr	Cal/m ² /hr	per cent	per cent
A	26	66	127	136	29.59	27.12	-17.11	-24.03
B	33	64	134	132	32.73	32.59	- 8.32	- 8.71
C	26	67	126	133	30.25	29.72	-15.27	-16.75
D	33	64	144	141	33.94	31.99	- 4.93	-10.39
E	37	65	141	141	31.90	31.61	-10.64	-11.46
F	37	63	135	140	29.77	28.39	-16.61	-20.48
Mean	32	65	134	137				

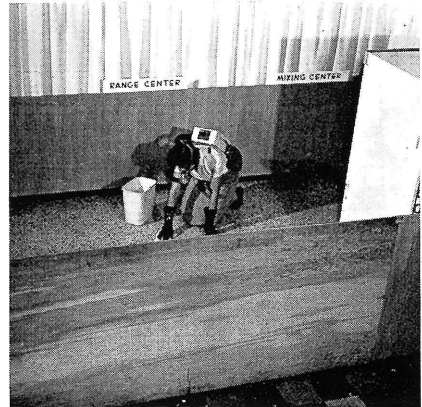
^aTo nearest birthday at beginning of study.

^bIn bare feet.

^cCorrected for weight of smock worn.

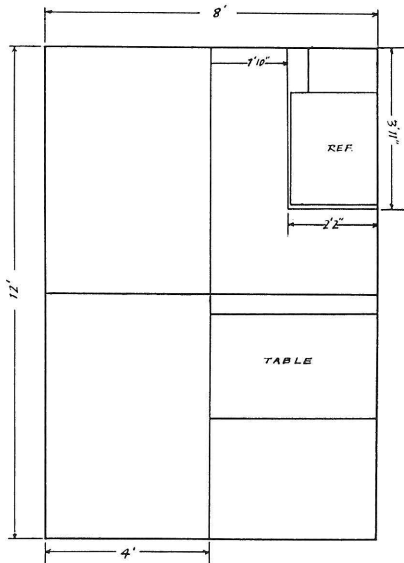
^dAccording to the Mayo Foundation Standard (Boothby, Berkson, and Dunn, 1936, Table 4).

Fig. 1.—Subject washing floor in laboratory kitchen area.



Dust, sand, soot, and grease were obtained from a garage area and a liquid soil (pH 8.75) was made with detergent and water. To prepare a floor for laboratory activities, 10 ml of soil were distributed with the floor machine, 1 tsp orange juice, 1 tsp milk, $\frac{1}{4}$ tsp catsup, and $\frac{1}{4}$ tsp bacon drippings were smeared by hand, and four shoe marks, each approximately 1 foot in length, were made at irregular intervals.

Selection of floor-care tools. Several criteria, including popularity with homemakers, were used for selecting tools for floor-care activities.



SCALE: $\frac{1}{2}'' = 1'0''$

Fig. 2.—Space available for floor-care activities.

The sponge mop was the top seller in the fall of 1960 according to the household cleaning department supervisor in a local department store.¹ Indianhead cloths for waxing and terry cloths for washing and rinsing were chosen for activities on hands and knees. A single-brush design floor machine was made available by the sponsor so similar models were not considered for the study. Guides found in the literature and limitations placed by items available determined selections of other tools. Activities performed in the laboratory and tools used are given in Table 2.

Initial interviews. Information about homemakers' usual methods of kitchen floor-care was obtained through interviews using a questionnaire. From the responses of homemakers, the most frequently reported

¹F. and R. Laporus Co., Town and High Streets, Columbus, Ohio.

TABLE 2. Mean Energy Expenditures of Six Subjects when Performing Floor-Care Activities.

Activity	Tool	Cal/min
All treatments		
Sweeping	Broom	2.93
Dust mopping	Dust mop	2.66
Washing	Terry cloth, on hands and knees	3.72
	Sponge mop	3.07
	Household floor machine and sponge mop	2.62
	Rinsing	Terry cloth, on hands and knees
Buffing	Sponge mop	3.00
	Household floor machine	2.03
Wax treatments only		
Waxing--(self-polishing wax)	Indianhead cloth, on hands and knees	3.30
	Cotton chenille applicer	2.61
Waxing--(paste wax)	Indianhead cloth, on hands and knees	3.81
	Lamb's wool applicer	2.87

interval for washing the floor (2 weeks) and the most commonly used detergent were adopted as practices for the study. Measurements for calculation of available kitchen floor areas were taken at the time of interviews.

PLAN FOR STUDY

Home study. The 6-month interval of home observations, January 2 through June 30, 1961, was divided into three periods—initial, experimental, and final.

During the initial period of approximately 1 month, homemakers continued to care for their kitchen floors by their usual methods.

In the experimental period, homemakers cared for kitchen floors according to assigned sequences of treatments—no-wax, self-polishing wax, and paste wax. Characteristics of kitchen floors and reactions of homemakers to prescribed floor-care practices were obtained by use of a rating scale and a check list. The 5-level rating scale was adapted from "Score Card for Condition of Smooth Floors" (Beveridge and Pond, 1960). A copy of the rating scale is in Appendix B. The appearance of floors was rated independently by homemakers and a research worker at six observation times during each period—at the beginning, preceding and following washings at 2-week intervals, and at the end of the 6-week period. Scores for each floor were obtained within 48 hours before washing or removing treatment and within 24 hours after treatment period began or floors had been washed and buffed. Self-polishing waxed floors were scored after washings as well as after buffings. At the end of each 6-week period, homemakers responded to a 10-item check list consisting of statements describing their reactions toward the prescribed floor-care practices.

Homemakers received directions concerning the following practices:

1. Soil and/or wax removal at the beginning of each 6-week period.
2. Use and care of tools for application of waxes and for buffing. Tools and supplies were provided for prescribed floor-care tasks—a sponge mop for washing, household floor machine for buffing, cotton chenille applicator for applying self-polishing wax, Indianhead cloth for applying paste wax on hands and knees, and a hand sponge for wiping spots and spills.
3. Daily recording of time spent performing freely chosen and prescribed floor-care activities.



Fig. 3.—Measurements of blood pressure and heart rate during preactivity period; meter reading is also being recorded.

4. Preparation of a solution² which was to contain 46 gm ($\frac{1}{4}$ cup) of a trisodium phosphate detergent dissolved in $1\frac{1}{2}$ gal of water (0.16 percent concentration of trisodium phosphate) at 37-40° C.

During the final period of approximately $2\frac{1}{2}$ weeks, each homemaker selected the floor treatment which she preferred and followed the same floor-care practices as prescribed during the experimental period.

Laboratory measurements. Activities were performed by each subject after eating a standardized lunch and resting in a sitting position for 20 minutes. Energy expenditure measurements of standing for 5 minutes were obtained in triplicate following the initial rest period.

Actual activity time was set at 5 minutes to provide an adequate size sample of expired air for analysis and to prevent fatigue which might occur with longer work periods. To determine recovery rates, measurements while standing relaxed after working were obtained for three consecutive 5-minute periods. The energy costs reported in this bulletin are those calculated for the duration of the activity itself and reduced to Calories per minute. Blood pressures and heart rates were measured at the beginning and end of the activity performance time and at the end of the three 5-minute recovery periods (Fig. 3). Following each 20-minute energy-determination interval, the subject sat relaxed for 5 minutes with gas meter removed.

²Since it was thought that waxes might be adversely affected by solutions used for washings as directed by the manufacturer, temperature recommended on the detergent box was reduced from hot to luke warm and the concentration was reduced by one-half.

Floor-care activities were performed first on floors without wax, then on floors prepared with self-polishing wax, and in turn with paste wax. The order for activities was rotated for each subject with each treatment to remove possible effects of fatigue, specific dynamic action of food, and/or oxygen debt. Measurements were made without duplication. Activities are pictured in Figures 1, 4-8 inc.

When a task was completed in less than the 5-minute period, performance time was recorded and the subject continued the task to complete the 5-minute interval. For an activity requiring over 5 minutes to complete, the activity was discontinued at the end of 5 minutes and the time cost of the total job was obtained subsequently.

Procedures for collection and analysis of expired air and calculation to Calories expended are given in detail in Ohio Agricultural Experiment Station Research Circular 121, August, 1963. Copies of detailed procedures and statistical analyses of data for the home and laboratory phases of the study are on file in the Home Economics Department, Ohio Agricultural Experiment Station, Columbus 10, Ohio.



Fig. 5.—Floor at right is being washed with floor machine.

Fig. 4.—Subject, left, washes or rinses with a sponge mop.



Fig. 6.—At right, floor is being buffed with floor machine.



Fig. 7.—Subject, left, is applying self-polishing wax.



Fig. 8.—Subject, right, uses circular motions in applying paste wax.



RESULTS AND DISCUSSION

ENERGY EXPENDITURES

Floor treatments. One objective of the study was to determine energy expenditures, blood pressures, and heart rates of women when performing floor-care activities on waxed, self-polishing and paste, and unwaxed floors in the laboratory. The data were analyzed using analysis of variance to test the significance of the differences in energy expended due to floor treatments. Differences were nonsignificant when energy expenditures were expressed either as gross Calories, Calories over preactivity standing, or Calories per square meter. Consequently, a mean of the three treatments for each of the activities studied was calculated and expressed as Calories per minute. The activities with corresponding mean Calorie expenditures per minute are given in Table 2. Energy costs in Calories per hour for each subject for activities on the three floor treatments are given in Appendix A, Table 6. All values were calculated from the 5-minute performance time following sitting at rest for 5 minutes and represent the energy expenditure per minute during activity only.

Figure 9 shows the energy cost of an activity in relation to pre-activity and recovery levels. It can be noted that the energy cost during recovery—bars 3, 4, and 5—decreased to a level comparable to initial standing cost, bar 1.

Comparing results with those reported in the literature is difficult because authors have presented energy costs in various ways and have not described tools used and methods of performance of activity in many cases.

The energy expenditure for sweeping found in the current study, 2.93 Cal/min, approaches the value given by Sherman (1952) of 2.81 Cal/min. Droese *et al.* (1949) and Garry *et al.* (1955) in determining the energy expenditure for the same activity found higher mean values—3.6 over basal value (approximately 1.0 Cal/min) and 3.9 Cal/min, respectively—than observed in the present study. Spector (1956) and Langworthy and Barott (1920) reported lower values—1.85 and 1.68 Cal/min, respectively. In the present study, although motions were similar for dust mopping and sweeping as performed in the laboratory, energy expended for dust mopping, 2.66 Cal/min, was lower than for sweeping. Of the eight activities the least energy was expended for buffing with a household floor machine, 2.03 Cal/min. Energy cost of polishing a floor as given by Garry *et al.* (1955), 5.1 Cal/min, was not identified as to method or tool used; the task may have been performed by hand.

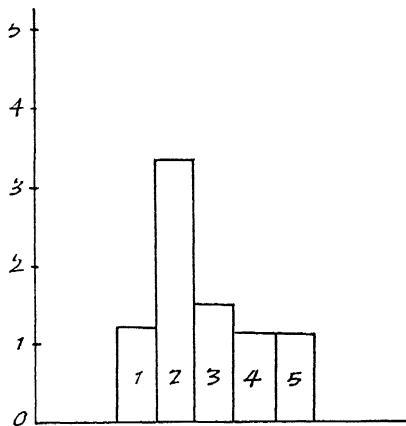


Fig. 9.—Energy expenditure during initial standing, activity, and recovery periods.

1 INITIAL STANDING
 2. ACTIVITY
 3-5. RECOVERY

Tools and methods. Another objective of the study was to obtain an energy expenditure basis for selecting tools and methods for performing floor-care tasks. Energy expended in washing floors appeared to be related to method of performing the task. Energy expenditure of the homemakers was significantly greater when they washed the floor on hands and knees than when they washed the floor in a standing position using either a sponge mop or household floor machine. Of the three methods the least energy was expended when using the household floor machine. The energy cost of washing the floor on hands and knees, 3.72 Cal/min, is comparable to a value for scrubbing, 3.6 Cal/min, given by Gordon (1957). Durnin *et al.* (1961) determined energy cost of the same activity and reported a value of 3.4 Cal/min. Droese *et al.* (1949) reported 4.9 Cal/min over basal value for this activity. These investigators did not describe the methods used in performing the tasks. In the present study, washing with a sponge mop required 3.07 Cal/min and with the household floor machine, 2.62 Cal/min.

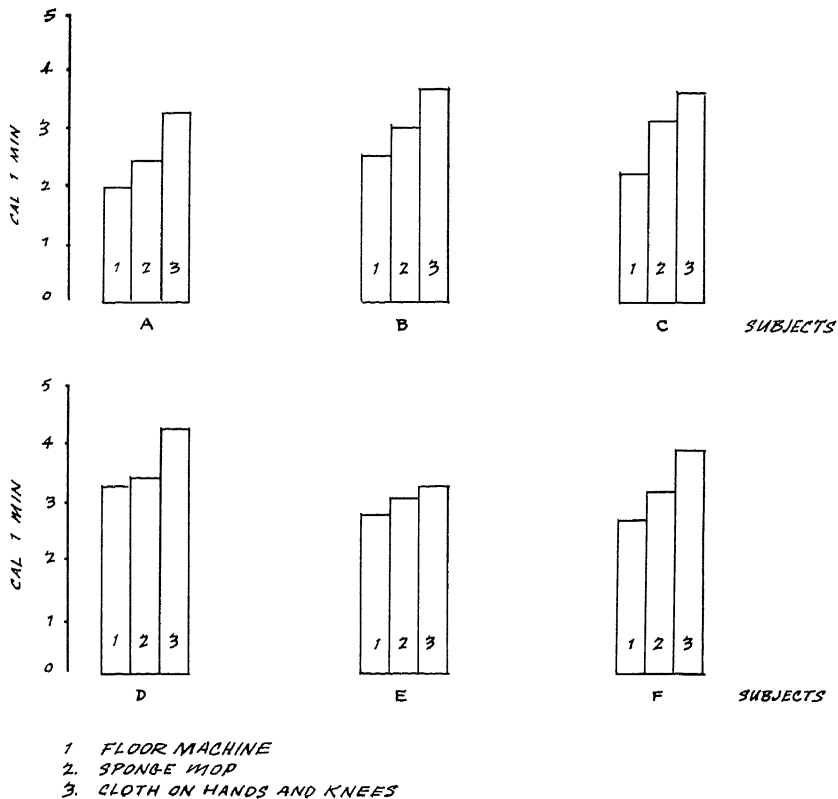
Energy expended for floor-care activities varied among subjects. When the floor was washed on hands and knees, Subject D consistently expended the greatest amount of energy expressed as Cal/min and Subject A, the least amount (Fig. 10). Subjects were instructed to

work at their usual rates. It appeared that Subjects C, D, and E worked with moderately rapid motions while Subject B worked slowly and thoroughly.

In the present study, energy costs were similar in washing and in rinsing the floor using the same tool—for example, 3.07 and 3.00 Cal/min, respectively, for the sponge mop. Although there were significant differences among the energy costs of activities, the difference between washing and rinsing was not significant.

Among activities performed on floors in wax treatments only, differences may be noted. Wax was applied from a hands and knees position and while standing. The energy expenditure for hands and knees was 3.30 Cal/min for applying self-polishing and 3.81 Cal/min for applying paste wax. Droese *et al.* (1949) reported 4.7 Cal/min over the basal value when applying paste wax on hands and knees.

Fig. 10.—Energy expenditure of six laboratory subjects during washing of floors by three methods.



In the present study, energy costs of applying wax using a standing position were less than when using a hands and knees position, 2.61 and 2.87 Cal/min for applying self-polishing wax with a cotton chenille applicator and paste wax with a lamb's wool applicator, respectively. The lamb's wool applicator method was considered unsatisfactory because of difficulty in getting an even wax layer.

While the energy cost of each activity was determined for a 5-minute period, each subject also performed all tasks to completion and the time required for each task was recorded. Means for the time required were calculated and are given in minutes per square yard of floor area (Table 3). More time was required for washing floors with the household floor machine and less time was used in sweeping and dust mopping than with any of the remaining activities.

Mean Calories per square yard were obtained by dividing mean Calories required for performing an activity to completion (total time cost multiplied by energy cost per minute for each subject) by 9.74 square yards in kitchen area. As can be noted, the energy cost per square yard for washing using the household floor machine and sponge mop approached that of washing on hands and knees, 3.993 and 4.326 Cal/sq yd, respectively, on floors protected with paste wax.

Of the wax application activities, the highest energy expenditure rate was obtained when applying paste wax with a cloth on hands and knees, 3.935 Cal/sq yd, and the lowest value for applying self-polishing wax with the cotton chenille applicator, 1.603 Cal/sq yd.

The rates at which Calories per hour and Calories per square meter per hour varied with blood pressures and heart rates were determined for the eight activities performed on the three floor treatments. In general, there was no relation between energy expenditure and blood pressures or heart rate.

TIME

Time records for the experimental part of the 6-month period were complete for 23 families. No attempt was made to identify persons within households who performed the floor-care activities. In most cases the homemaker performed these tasks. Time per day for each task was determined by dividing total time spent performing the activity by number of days in the treatment period. Mean time costs were calculated for each activity on each treatment and reduced to the square yard basis (Table 4).

Homemakers spent more time per day per square yard in washing with the sponge mop than in any other activity. Time cost for applying

paste wax was almost twice that for applying self-polishing wax. Costs for dust mopping and vacuuming were quite low; one reason was that the time spent by approximately half the homemakers (Table 4) who performed each of these tasks was divided by the total number.

Homemakers spent similar amounts of time in washing with a sponge mop, dust mopping, sweeping, and vacuuming on the three types of floors and in applying the two waxes. The time spent buffing paste waxed floors was significantly greater than time spent buffing no-wax and self-polishing waxed floors.

The 23 homemakers spent on the average less than 0.5 minute per day per square yard in floor-care activities during each of the 6-week periods. These activities included those tasks given in Table 4 and in addition the wiping of spots and spills. The most time per day per square yard was spent on floors with paste wax (0.470 min) and the least on self-polishing waxed floors (0.320 min). Time per day per square yard for no wax was 0.361 min. The differences were significant at the 0.01 level.

Time ranged from 0.143 to 0.847 min/day/sq yd when the three treatments were considered as a whole. Time spent washing with a sponge mop, dust mopping, sweeping, and vacuuming expressed as

TABLE 3.—Mean Time Costs and Mean Energy Costs Per Square Yard for Floor-Care Activities Performed in the Laboratory.

Activity	Treatment					
	No-wax		Self-polishing wax		Paste wax	
All treatments						
	min	Cal/ sq yd	min	Cal/ sq yd	min	Cal/ sq yd
Sweeping	0.227	0.689	0.227	0.653	0.226	0.648
Dust mopping	0.253	0.689	0.180	0.449	0.168	0.460
Washing						
Terry cloth, on hands and knees	1.217	4.457	1.305	4.917	1.189	4.326
Sponge mop	1.308	3.935	0.911	2.704	0.885	2.766
Household floor machine	2.051	5.240	1.675	4.134	1.495	3.993
Rinsing						
Terry cloth, on hands and knees	0.868	3.128	0.830	3.089	0.730	2.782
Sponge mop	0.701	2.045	0.808	2.458	0.674	1.991
Buffing	0.484	0.991	0.510	0.999	0.484	0.914
Wax treatments only						
Waxing--(self-polishing wax)						
Indianhead cloth, on hands and knees			0.752	2.387		
Cotton chenille applicator			0.614	1.603		
Waxing--(paste wax)						
Indianhead cloth, on hands and knees					1.051	3.935
Lamb's wool applicator					0.918	2.692

TABLE 4.—Calculated Energy Expenditure of Women in Caring for Floors in the Home Based on Average Time Spent for Each Task and Energy Cost Determined in the Laboratory.

Activity (1)	Cal/ min (2)	Min/ day/ sq yd (3)	Cal/ day/ sq yd (4)	Frequency of homemakers performing task in 6-week period (5)
No-wax treatment				
Buffing, floor machine	2.11	0.042	0.089	23
Dust mopping	2.71	0.005	0.014	12
Sweeping	3.02	0.055	0.166	20
Vacuuming	. . .	0.003	. . .	16
Washing, sponge mop	3.01	0.130	0.391	23
Self-polishing wax				
Applying wax, cotton chenille applicator	2.61	0.040	0.104	23
Buffing, floor machine	2.05	0.044	0.090	23
Dust mopping	2.51	0.005	0.013	11
Sweeping	2.88	0.052	0.150	21
Vacuuming	. . .	0.003	. . .	17
Washing, sponge mop	3.03	0.136	0.412	23
Paste wax				
Applying wax, hands and knees	3.81	0.073	0.278	23
Buffing, floor machine	1.94	0.116 ^a	0.225	23
Dust mopping	2.75	0.005	0.014	12
Sweeping	2.89	0.057	0.165	20
Vacuuming	. . .	0.001	. . .	16
Washing, sponge mop	3.17	0.130	0.412	23

^aAfter applying wax and after washings.

minutes per day per square yard varied significantly among subjects. In general, more time was spent on floor-care activities by homemakers with larger families than by those with smaller ones (Table 5).

Families were identified as to stage in family life cycle (Duvall, 1957, p. 8) which is based on age of the oldest child. Of the three stages identified for this study, families in each succeeding stage, re-

TABLE 5.—Mean Time Per Day Per Square Yard Spent in Floor-Care Activities According to Size of Family.

Number in family	Frequency of family size	Mean min/day/sq yd
7	2	0.575
6	3	0.345
5	12	0.378
4	6	0.348

ardless of size, spent less time with floor care. In other words, families with younger children spent more time in caring for their floors than did those with older children.

PRESCRIBED PRACTICES DURING EXPERIMENTAL PERIOD

A third objective of the study was to evaluate the appearance of floors and to obtain reactions of participants to prescribed floor-care practices during an experimental period. A rating scale was used independently by homemakers and two research persons to evaluate the appearance of floors at specified times during each 6-week treatment period. Reactions of homemakers toward floor-care practices were obtained by using a check list at the end of each 6-week period.

Appearance of floors. Characteristics described in the rating scale were: A, general appearance; B, marks and dents; C, dust; D, food particles and spots; E, wax layer; F, discoloration; G, stickiness. Each characteristic was given a rating in whole numbers ranging from a high score of 5 to a low of 1. A copy of the rating scale is found in Appendix B.

Scores of homemakers for each treatment were significantly lower than those of the research persons for marks and dents, food particles and spots, discoloration, and stickiness and higher for wax layer. Scores of the two groups for general appearance and dust did not differ.

Scores for each characteristic for each of the three treatments were compared and were highly significant for general appearance, marks and dents, dust, and wax layer. Ratings of general appearance were highest for self-polishing waxed floors and lowest for floors without wax. The ratings for condition of wax layer were higher for self-polishing than for paste wax. Ratings of marks and dents and dust

were highest for paste wax and lowest for floors without wax. The scores for these four characteristics—A, B, C, and E—approach a normal distribution.

Values for four characteristics of unwaxed floors and seven of waxed floors were determined at six observation times. Scores of homemakers and research persons were combined and means were calculated for each characteristic with each of the three floor treatments. The means are given according to observation times in Appendix A, Table 7. In general, ratings were higher at the beginning of the period and following washings and buffings than preceding washings and at the end of the 6-week period when floors were soiled (Fig. 11).

The coefficient of correlation for ratings of general appearance with wax layer was significant at less than the 0.01 level. For the two wax treatments, scores for these two characteristics were similar at the beginning of the period. After 2 weeks, scores for the two treatments remained similar for each of these characteristics but ratings for wax layer were higher than those for general appearance. Ratings for both characteristics increased after washing and buffing. Ratings for self-polishing wax for both characteristics reached approximately the level of the beginning of the period whereas those for paste wax were considerably lower than those at the beginning. This same pattern of change in these characteristics continued for these two treatments during the remainder of the 6-week period. Based on these observations it would appear that the self-polishing wax gave the homemaker a protective coating which remained on the floor and responded to washings and buffings during the 6-week period.

Scores at two additional observation times (nos. 3 and 5 in Appendix A, Table 7) after each of the two washings and before buffing, were obtained on self-polishing waxed floors only. Ratings at these times for general appearance were similar to scores of floors without wax which had been washed and buffed. After buffing, scores for both general appearance and wax layer increased considerably (Fig. 11).

The r value for ratings of general appearance with marks and dents was significant at the 0.06 level. The extent to which permanent marks and dents and/or removable marks influenced the scoring of general appearance cannot be determined. Scores for marks and dents for each of the three treatments varied less throughout the 6-week period than did scores for general appearance.

One difference in scores for general appearance and for marks and dents is related to wax treatments. There was little difference

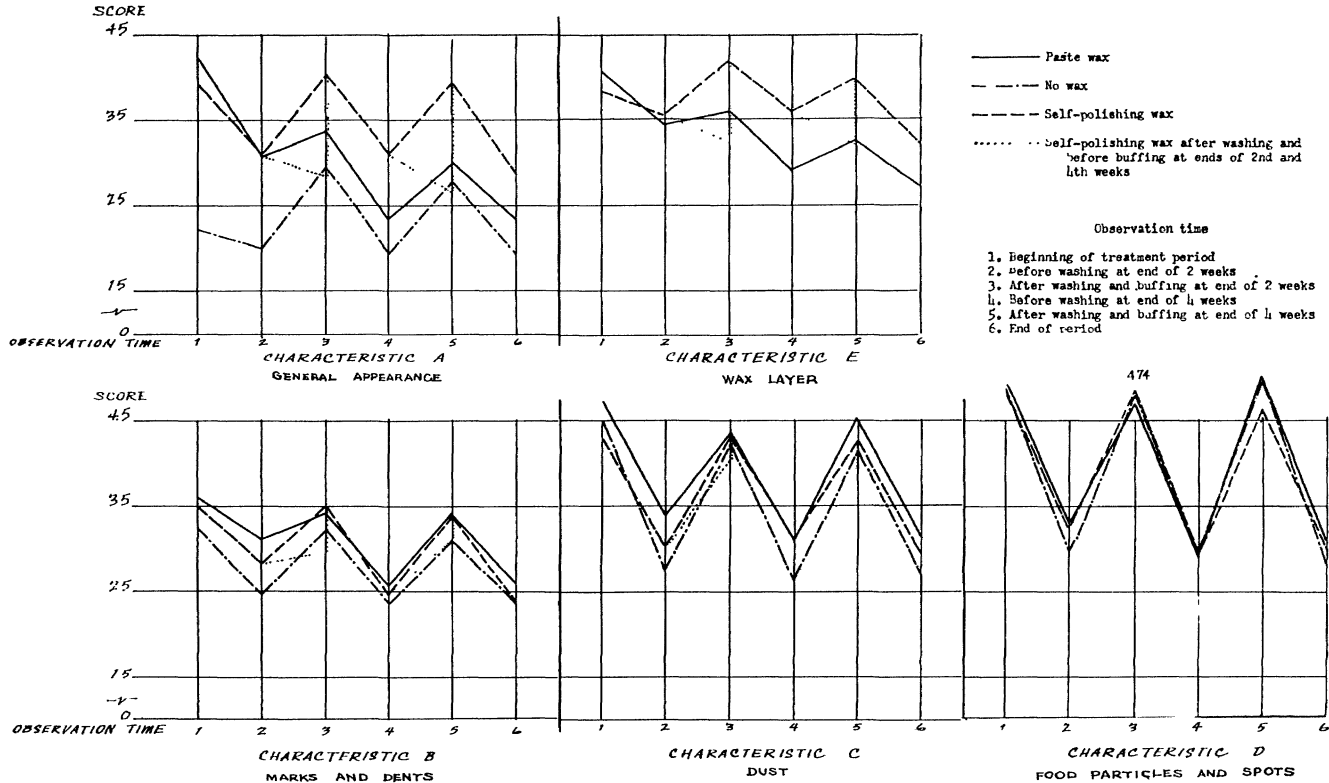


Fig. 11.—Comparison of scores of characteristics at different observation times during 6-week period.

in ratings of marks and dents due to kind of wax used whereas the ratings of general appearance showed considerable difference after the first 2 weeks. The no-wax treatment scores for marks and dents followed those of the wax treatments more closely than did general appearance scores.

Scores for dust and for food particles and spots followed similar patterns and the ranges of scores for both characteristics were greater than those for other characteristics throughout the 6-week period. Ratings for these two characteristics were not associated with general appearance scores as indicated by low and nonsignificant r values.

Since wax, if present, was removed at the beginning of each 6-week period, discoloration and stickiness due to previous waxings were not encountered. The r value of general appearance ratings with discoloration scores was significant at less than the 0.025 level; the r of general appearance with stickiness was nonsignificant. Mean values of both characteristics were quite high and distributions were skewed to the left.

Differences in ratings preceding washings and those after washings and buffings were highly significant for characteristics A through E and significant for F for each of the three treatments.

Mean scores of each characteristic were determined for floors which were identified by years in use. Scores usually decreased as the age of flooring material increased. Scores of general appearance for self-polishing wax were not significantly different for the three age groups; while for no-wax and paste, scores for the newest and oldest floor were significantly different. Scores for marks and dents for the three treatments were significantly different between "0 through 2" years and "11 or more" years. All other ratings except for food particles and spots were similar for the three age groups.

Reactions of homemakers. A frequency of responses of homemakers to items in the check list are given in Appendix A, Table 8. Some items with high and low frequencies need further consideration.

Of the 17 homemakers who preferred their own method to that prescribed for the no-wax treatment (item 1), 16 had used wax prior to the study, 13 of whom had used self-polishing wax. Ten of the 11 homemakers who preferred their own method to the prescribed paste treatment used self-polishing wax at the beginning of the study.

Prior to the study the predominating pattern of the homemakers who thought that the floor needed washing more frequently than every 2 weeks (item 2) had been that of washing the floor every 2 to 4 weeks and damp mopping at weekly intervals between washings. Damp mopping was described in various ways, use of several tools and water

ranging in temperature from hot to cold with varying amounts of detergent were mentioned.

Initially, 11 homemakers had been washing their floors on hands and knees. Six of the homemakers who found the sponge mop easy to use (item 4) had used it at the beginning of the study and five others had used string mops. One participant used a floor washer.

The satisfaction expressed by 17 homemakers with the appearance of self-polishing waxed floors at the beginning of the 6-week period (item 8) and after washings and buffings (item 9) was supported by high scores for general appearance of floors at these observation times. The decrease in number of homemakers liking the appearance of paste wax floors after washings and buffings was associated with a decrease in scores for general appearance.

Twelve homemakers indicated that they thought that paste wax should have been applied more frequently than every 6 weeks, and only six indicated that more frequent applications of self-polishing wax were needed (item 10). From one to three coats of wax were used on each floor at the beginning of each wax treatment period.

During interviews following the study, homemakers were asked their preferences for the three floor treatments. Sixteen participants indicated strong preference for the self-polishing wax treatment.

SUMMARY

Objectives of the study were (1) to determine energy expenditures, blood pressures, and heart rates of women when performing floor-care activities on waxed and unwaxed floors; (2) to obtain an energy expenditure basis for selecting tools and methods for performing floor-care tasks; (3) to evaluate the appearance of floors and to obtain reactions of participants to prescribed floor-care practices during an experimental period.

Initially, information about floor care practices of 25 homemakers was obtained and used in determining some practices to be followed during the study and in comparing reactions of participants to the prescribed activities.

In the laboratory, samples of expired air were collected and analyzed for oxygen content for six subjects working under controlled conditions. Subjects performed floor-care activities for 5 minutes and then stood for a recovery period of three consecutive 5-minute intervals. The oxygen data were converted to energy costs for the duration of the activity exclusive of recovery. Mean energy expenditures in Calories per minute for each activity (dust mopping, sweeping, washing—

with a cloth on hands and knees, with a sponge mop, and with a floor machine—rinsing with a cloth on hands and knees and with a sponge mop, and buffing) were calculated since differences due to floor treatments were not significant. Measurements of blood pressures and heart rates were recorded also.

In the home study, 25 homemakers (the six laboratory participants and 19 others) followed prescribed practices and recorded time spent in kitchen floor-care activities (sweeping, dust mopping, vacuuming, washing with a sponge mop, applying self-polishing wax with a cotton chenille applicator and paste wax with a cloth, buffing with a floor machine, and wiping spots and spills) for three 6-week intervals according to assigned sequences of treatments—no-wax, self-polishing wax, and paste wax. During each treatment period, appearance of floors was determined and reactions of participants to prescribed floor-care activities were obtained.

Data from the laboratory measurements may be summarized as follows:

For activities performed with only one tool—sweeping, dust mopping, and buffing—energy expenditures were 2.93, 2.66, and 2.03 Cal/min, respectively.

Energy costs varied with the use of different methods and tools for the same activity. Washing with a cloth on hands and knees required 3.72 Cal/min; with a sponge mop 3.07 Cal/min; and with a floor machine, 2.62 Cal/min. Energy cost when washing or rinsing on hands and knees was significantly greater than when washing or rinsing with a tool used in a standing position. Of activities performed on waxed floors only, costs of applying self-polishing and paste waxes on hands and knees were 3.30 and 3.81 Cal/min, respectively. Lower values were obtained with long-handle applicators—2.61 and 2.87 Cal/min when applying self-polishing and paste waxes, respectively.

Time, expressed as mean minutes per square yard, spent by the laboratory subjects in performing floor-care activities to completion varied for the activities. Washing floors with the household floor machine required more time and sweeping and dust mopping consumed less time than did any of the other activities.

When the mean energy cost for each task was calculated using time spent per square yard and the determined energy rate of each subject, energy expenditures were similar for washing with the floor machine and with a cloth on hands and knees. For example, washing floors protected with paste wax by these two methods required 3.993 and 4.326 Cal/sq yd, respectively.

Of the wax application activities, applying self-polishing wax with the cotton chenille applicator, required the lowest energy expenditure rate.

In general, no relationship was found between changes in energy expenditure and changes in blood pressures and heart rates.

In the home study, records indicated that homemakers spent the most time caring for floors prepared with paste wax, 0.470 min/day/sq yd, compared with 0.320 on self-polishing waxed floors and 0.361 on floors without wax. The time for individual activities ranged from 0.001 min/day/sq yd in vacuuming a paste waxed floor to 0.136 min/day/sq yd for washing a self-polishing waxed floor with a sponge mop. For applying self-polishing and paste waxes, 0.040 and 0.073 min/day/sq yd, respectively, were spent.

Time spent in buffing was highest on paste waxed floors and lowest for floors with no wax, and the difference was significant. No differences were found in time spent in other floor-care activities when performed on either waxed or unwaxed floors.

For tasks performed by homemakers on floors in each of the three treatments, energy expenditures were calculated by multiplying mean time spent per day per square yard by the homemakers and mean energy rates of the laboratory participants.

The appearance of each kitchen floor was determined at regular intervals within each 6-week period. Characteristics evaluated were general appearance, marks and dents, food particles and spots, wax layer discoloration, and stickiness. Scores for general appearance were associated with scores for marks and dents, condition of wax layer, and extent of discoloration.

Favorable reactions of homemakers at the end of each 6-week period to statements describing the appearance of floors were supported by high scores of floor characteristics at beginning of treatments and after washings and buffings.

IMPLICATIONS

Results of this study indicated that body position of the worker while performing floor-care tasks was related to energy expenditure rate. The higher cost of working on hands and knees compared with standing may have been partially dependent on weight lifted and size of muscles involved. Laboratory subjects in this study were selected within limits for weight, height, and age. Data obtained on these subjects cannot be considered directly applicable for women who vary in body build from the limits used. Additional research is needed to determine the suitability of these results for women of other age groups and body builds.

Laboratory subjects performed floor-care activities at their own rates of work in this study. For a person who works at a fast rate, these results may not be applicable since these women worked at slow to moderate rates.

In this study, energy costs of floor-care activities performed for 5 minutes may be considered within the range of very light and light work. Further research is needed to determine the energy rates for varying lengths of time spent in activity performance and the relation of these rates to recovery.

A continuous recording device for determining heart rates during an activity would show changes in rates which were not possible in this study, and might give a basis for using heart rate as the criterion for limits within which persons would work over a period of time. The correlation of energy cost and heart rate might be used as an indication of intensity of activity.

In comparing tools for given tasks, the rate of energy expended and energy cost per job may be used as criteria. With a given tool, efficiency in terms of energy cost may be determined for different ways of using the tool. This approach may also be of interest to manufacturers in designing tools which complement the physical characteristics of the worker.

The appearance of floors may vary with methods and tools used in floor-care activities. For optimum satisfaction, homemakers may find the use of complementary floor-care practices more desirable than the routine performance of tasks. Use of a glossmeter or reflectometer for determining appearance of floors would give more objective measurements than was possible with the rating scale.

The acceptance of responsibility for the performance of floor-care activities and the motivation needed for the execution of various floor-care tasks are important factors in understanding reactions of homemakers in caring for floors. Additional work is needed to further understand reactions of homemakers toward floor-care activities as well as other household tasks.

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APPENDIX A

TABLE 6.—Calories Per Hour of 6 Subjects When Performing Floor-Care Activities.

Activity	Subject						Mean
	A	B	C	D	E	F	
No wax							
Sweeping	165	177	189	194	199	164	181
Dust mopping	149	140	150	177	196	162	162
Washing							
Cloth, on hands and knees	214	220	221	236	220	206	219
Sponge mop	174	170	187	200	179	174	181
Floor machine	130	136	138	203	169	157	156
Rinsing							
Cloth, on hands and knees	183	197	206	243	236	229	216
Sponge mop	163	154	198	212	169	163	177
Buffing	118	123	116	145	154	102	126
Self-polishing wax							
Sweeping	161	198	159	157	179	181	173
Dust mopping	117	163	150	161	154	160	151
Washing							
Cloth, on hands and knees	201	230	232	270	201	253	231
Sponge mop	125	189	196	209	185	188	182
Floor machine	116	168	136	177	157	149	151
Rinsing							
Cloth, on hands and knees	173	229	204	316	227	253	234
Sponge mop	176	182	179	233	153	188	185
Buffing	120	133	86	161	132	106	123

TABLE 6. (Continued)—Calories Per Hour of 6 Subjects When Performing Floor-Care Activities.

Activity	A	B	C	Subject D	E	F	Mean
Paste wax							
Sweeping	168	181	165	181	160	185	173
Dust mopping	129	155	159	194	176	178	165
Washing							
Cloth, on hands and knees	184	213	212	265	188	251	219
Sponge mop	143	202	187	207	186	214	190
Floor machine	124	166	140	208	174	179	165
Rinsing							
Cloth, on hands and knees	192	212	213	325	221	234	233
Sponge mop	148	176	186	231	149	198	178
Buffing	104	133	94	150	111	106	116
Wax treatment only							
Waxing--(self-polishing wax)							
Cloth, on hands and knees	155	194	181	247	198	214	198
Cotton chenille applicer	152	161	144	190	122	170	156
Waxing--(paste wax)							
Cloth, on hands and knees	186	209	231	260	246	241	229
Lamb's wool applicer	129	165	168	220	180	172	172

TABLE 7.—Mean Scores of Characteristics at Each Observation Time During Experimental Period.

Observation time	Characteristic						
	A	B	C	D	E	F	G
1. Beginning of treatment period							
No-wax	2.20	3.25	4.51	4.82			
Self-polishing wax	3.92	3.50	4.36	4.80	3.83	4.74	4.93
Paste wax	4.22	3.59	4.75	4.88	4.11	4.71	4.88
2. Before washing at end of 2 weeks							
No-wax	2.00	2.44	2.80	2.93			
Self-polishing wax	3.10	2.80	3.04	3.15	3.56	4.57	4.88
Paste wax	3.08	2.86	3.42	3.23	3.47	4.48	4.90
3. After washing at end of 2 weeks							
Self-polishing wax	2.86	2.96	4.09	4.74	3.23	4.62	4.90
After washing and buffing at end of 2 weeks							
No-wax	2.97	3.21	4.31	4.74			
Self-polishing wax	4.06	3.47	4.36	4.81	4.21	4.72	4.94
Paste wax	3.38	3.40	4.40	4.69	3.59	4.54	4.94
4. Before washing at end of 4 weeks							
No-wax	1.92	2.34	2.60	2.84			
Self-polishing wax	3.07	2.46	3.16	2.92	3.59	4.54	4.78
Paste wax	2.34	2.54	3.15	2.94	2.94	4.58	4.75
5. After washing at end of 4 weeks							
Self-polishing wax	2.65	3.12	4.15	4.53	3.22	4.72	4.90
After washing and buffing at end of 4 weeks							
No-wax	2.79	3.10	4.15	4.68			
Self-polishing wax	3.96	3.34	4.27	4.56	3.99	4.73	4.98
Paste wax	3.00	3.38	4.54	4.73	3.27	4.55	4.87
6. End of period							
No-wax	1.91	2.40	2.66	2.82			
Self-polishing wax	2.86	2.38	2.90	2.94	3.25	4.55	4.81
Paste wax	2.32	2.62	3.13	3.00	2.72	4.47	4.75

TABLE 8.—Frequency of 24 Homemakers' Responses to Check List Items on Kitchen Floor-Care.

Item	Floor treatment			Total homemakers checking item
	No-wax	Self-polishing	Paste	
1. Prefer own method of kitchen floor care to prescribed method	17	4	11	18
2. Feel floor needed to be washed more frequently than once every 2 weeks	19	10	9	21
3. Believe floor needed to be rinsed after it was washed	4	2	4	6
4. Found sponge mop easy to use	17	21	21	23
5. Like results obtained when washing floor with sponge mop	14	17	16	18
6. Would like to have been able to remove shoe marks from floor	13	12	14	17
7. Would like to have been permitted to buff floor more frequently than once every 2 weeks	8	11	9	16
8. Was pleased with appearance of floor immediately after treatment was given at beginning of this 6-week period	9	17	18	23
9. Like appearance of floor after it was washed and buffed at the end of the second week and at the end of the fourth week of this period	11	19	9	22
10. Believe floor needed waxing more frequently than once every 6 weeks	. .	6	12	13

APPENDIX B

Date _____ Hour _____ Family number _____ Method of floor care _____ Rater _____

RATING SCALE FOR KITCHEN FLOORS

We want you to score your kitchen floor as it seems to you, not to anyone else. Look at your kitchen floor closely and test with your hand for the feel of the floor surface; encircle the number that best describes the condition of the floor.

For example, to score item A below when the floor surface is slightly glossy and smooth you would give a rating of 3. On the other hand, if the floor condition is better than the rating of 1 and not high enough to receive a rating of 3, then a score of 2 would be given. Likewise, a rating of 4 would be given when the condition of the floor would be above a rating of 3 and below the rating of 5 which indicates that the floor has a high or satiny even gloss.

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	Dull, streaked porous surface	2	Slightly glossy, and/or streaked, smooth surface	4	High or satiny even gloss	Comments	
A. General appearance	1		3		5		
B. Marks and dents	Conspicuous and permanent marks, scratches, and/or dents	1	2	A few small dents and/or scratches; removable marks	3	4	Free of marks, scratches, and/or dents from shoes, furniture or other objects
C. Dust	Very dusty under kitchen table, in corners, in toe spaces; a noticeable amount of mud and/or grit tracked on or ground in	1	2	Somewhat dusty or gritty all over or under kitchen table, in corners, in toe spaces; a small amount of mud or grit tracked on or ground in	3	4	Free of dust and/or mud; smooth to touch
	1		2		3	4	5

RATING SCALE FOR KITCHEN FLOORS (Continued)

						Comments
D. Food particles and spots	A noticeable amount of food particles or spots due to liquids near work centers and eating area		A small amount of food particles or spots due to liquids near work centers and/or in eating area		Free of food particles and spots	
	1	2	3	4	5	
<p>If there is any wax on the floor, continue scoring on these 3 characteristics. If there is no wax, disregard this part of the score card.</p>						
E. Wax layer	Decidedly streaked with wax and/or appears to have a very heavy coat of wax		Somewhat streaked due to too much or too small an amount of wax		Completely free of wax streaks; appears to have a thin uniform layer of wax	
	1	2	3	4	5	
F. Discoloration	Very discolored due to coats of old wax over the entire floor, near base-boards and appliances, in corners, in toe space areas		Somewhat discolored over free floor space or near base-boards and appliances, in corners, in toe space areas		Absence of discoloration due to coats of old wax	
	1	2	3	4	5	
G. Stickiness	Quite sticky over entire floor area or in particular areas		Somewhat sticky where there is no traffic		No trace of stickiness	
	1	2	3	4	5	