A HUMAN FACTORS EVALUATION OF THE AMERICAN KITCHEN

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ABSTRACT

Kitchen design is evaluated using counter space, counter location and counter height as the criteria. A survey of apartment kitchens showed that designers generally follow the guidelines for total counter space, but the allocation of counter space to the different work centers makes the designs inadequate. An experimental study shows that the standard 36" high counter surface is not at the correct height for many kitchen tasks and a simple, economical design for adjustable cabinets is presented.

INTRODUCTION

The kitchen is a workplace. As such, it deserves the same attention to detail as any factory assembly line. Kitchens should be built with the housewife in mind by making her chores easier and more pleasant, saving her steps where possible, and giving her sufficient work areas and storage space. The ideal way to design a kitchen is to make it fit the specific person who is going to use it. This is only practical if you are building your own house. Generally, the anthropometric data available can be used to ensure a kitchen design agreeable to <u>most</u> women, but this is not much consolation to the 4'11" woman or 6'4" man trying to create a culinary masterpiece.

Kitchen design principles have stressed improvement of the kitchen worker's efficiency and reduction of the human energy requirement. Kirpatrick (1958) states these objectives differently: save the homemaker steps and decrease hours of work in the kitchen. Perhaps both these objectives for kitchen design are remiss in that satisfying them does not necessarily remove the fatigue and discomfort component caused by too low or too high counters, sinks, ovens, etc. Bratton (1959) has suggested that energy cost is probably not the most important factor in the fatigue of standing. Anyone who has stood at attention or even at ease for prolonged periods will recall some amount of fatigue. The next logical step is to specify <u>three</u> key considerations for designers to heed in kitchen planning: efficiency or time saving, energy or step saving, and fatigue.

After completing her study of ironing heights, Knowles (1946) concluded that the homemaker should be most concerned with two things: an awareness of needs and adjustable height equipment for major tasks. Counter heights have been at 36 inches for so long that people have become accustomed to the "standard" and naturally assume it is sufficient and unchangeable. Given an opportunity to try other counter heights or ironing heights, many people have been surprised at the difference three to four inches can make.

The relative obscurity of the counter height problem is definitely not shared with that of counter space or frontage. In an apartment, the lack of such space is particularly annoying. How often is the setting of the table delayed until the last minute because the table is an essential addition to the counter space?

The emphasis of this paper is the location, amount and height of kitchen counter space in apartment complexes. The results of an apartment survey is presented, the results of an experiment on the effect of counter height on a mixing task is discussed, and an economical cabinet design is presented which permits adjustment to the height of the worker.

APARTMENT KITCHEN SURVEY

The first step in this study of apartment kitchens consisted of a survey of various apartment complexes in Norman, Oklahoma, and San Antonio, Texas. Some accepted guidelines for kitchen counter layout and criteria for evaluating a kitchen work place will be discussed prior to the survey results and analysis.

For years, the number one criterion for kitchen evaluation has been based on the three major kitchen appliances: refrigerator, range, and sink. According to the criterion, these appliances must be situated in some sort of triangular arrangement, hence the concept of a "work triangle". Parallel-wall, U-shape, and L-shape kitchens are the predominant traditional designs. In the first, two major appliances are located along one wall while the third would be along the opposite wall. In the second, one appliance would be located on each of three walls. The third layout is like the first except the two walls are adjacent rather than opposite. All three plans are based on a triangle. Of course, there are many variations of these layouts, but the triangle criterion usually holds true. A poorly designed kitchen, for instance, would be one in which all three major appliances were located along the same wall, i.e., the pullman. Unfortunately, this type is necessary, though, where space is the major consideration.

There is considerable latitude in planning the work triangle or "vital triangle" as Spencer (1971) has named it. Generally, the length of the work triangle, defined as the sum of the distances between the center front of the sink, range, and refrigerator, should be no less than 14 feet and no greater than 23 feet. Each individual leg should be between 4'6" and 7'6" and is dependent on the layout used. The counter space is of particular interest and is at least partially defined by the legs of the work triangle. It is obvious that a kitchen with a 23 foot work triangle will most likely have more counter space than one with a 14 foot triangle; if not, you can be assured there is much wasted space. A major problem is that of "slick kitchen uniformity", a phrase coined by Gutheim (1948). A kitchen with even surfaces throughout may be aesthetically appealing but certainly is not work oriented. For instance, if the rim of the sink is lined up with the counter top, then the sink is at least six inches too low. If the cooking surface of the range is at the correct height, then the oven is too low, assuming a traditional combined oven/cooktop.

The recommended counter space for kitchens is well-documented for houses but not much has been written on the unique problems of apartments. The standards published by the Illinois Small Homes Council (Kapple, 1965) are used in many of the home economics texts and magazines. The Council bases its recommendations on the size of the house with three different sets of standards listed for houses less than 1,000 square feet, greater than 1,400 square feet, and those within that range. The following discussion will be limited to the under 1,000 square feet recommendations, since the apartments surveyed were about 700 to 900 square feet.

Data were collected from seven garden apartment complexes in Norman and four in San Antonio. All the apartments were generally the same size with two bedrooms, a living room, kitchen, dinette, and bath (two baths in two cases). Rentals in 1974 ranged from $160 to $260 per month with San Antonio about $20 higher than Norman for an equivalent apartment. All but two of the apartments were constructed in the past five years. Rather unexpectedly, the best overall kitchen was found in one of the two older apartments. It is interesting to note that with one exception (the most expensive apartment), there was no apparent relationship between rent and size/design of the kitchens. The differences in rental were primarily due to "extras", such as fireplaces, patios, washer/dryer connections, tennis courts, etc.

Seven of the kitchens are smaller than the suggested minimum. The individual legs of the triangles follow suit. The most unexpected observation is a substandard work triangle distance does not mean there is a lack of counter space. The kitchens with the most counter frontage all fail to meet the work triangle standard. Yet, the kitchen with the least frontage easily meets the triangle standard. The paradox is explained simply in that the apartment has much wasted space between opposite walls; although the sink and refrigerator are opposite one another, there is seven feet of space between them. In the case of the other four kitchens, the working space between opposite counters is only three to four feet. Both situations are less than adequate. An optimal five feet, but no less than four and a half feet, should be provided between opposite counters or major appliances to allow two people to work comfortably without colliding continually.

The parallel-type kitchen is by far the most popular for the apartments in this survey at least, although the L-shape yields more working area and flexibility of design. The U-shape is generally recognized as best for houses but tends to be too small when put in an apartment. The parallel-type kitchen is more convenient when space restrictions are a factor, which explains its wide-spread use.

All the kitchens in the survey have sufficient total counter frontage (from 68 to 88 inches). Unfortunately, in most cases, the frontage is poorly located. Two are severely handicapped by lack of counter space on one side of the sink. This may not seem important to those people who have become accustomed to a dishwashing or preparation/clean-up sequence with counters on both sides of the sink taken for granted, but it is inconvenient at the least and totally frustrating at times not to have counter space on both sides of the sink.

Another problem noted in the application of the standards is the tendency to limit common counter space between the range and refrigerator to 15 or so inches. Appliances sharing common counter frontage should use the longer recommended frontage plus one foot. In eight apartments, the range and refrigerator share a common counter, yet the frontage provided is sufficient in only four cases. Only three kitchens have the recommended counter frontage for a mixing area. Five others, though, have 30 or more inches of uninterrupted frontage frontage for a mixing area. Five others, though, have 30 or more inches of uninterrupted frontage which is probably sufficient in most cases. Under 30 inches is marginal at best.

It is easy to see what has been happening in apartment design. Architects and cabinet builders have attempted to provide sufficient total counter frontage but in doing so have not left sufficient uninterrupted counter frontage.

ERGONOMIC ASPECTS OF ADJUSTABLE COUNTERS

An experiment was designed to determine the effect of counter height on a woman's cardiovascular system while she was working at a representative kitchen task. A mixing task was chosen as most likely to show a difference in the body's response to working at different surface heights.

Eight subjects were selected solely on the basis of stature and willingness to participate. Three subjects were shorter than 62 inches, three were of average height (62-66 inches) and two were taller than 67 inches. All but one of the subjects were 20-25 years old. Although the subjects' frames varied from large to small bone structures, all were more nearly average weight (proportionately to height) than heavy set or thin.

Each subject's stature and elbow height were measured and recorded. The elbow height was measured with the upper arm vertical and against the body and the forearm parallel to the floor. The women wore clothing, including footwear, similar to that they normally wear while working in the kitchen. All but one subject, who preferred bare feet, wore low-heeled shoes. The average stature was 65 inches and the average elbow height 40.5 inches.

Each subject completed two trials in the same day: one at a counter height of 36 inches and the other at a counter height adjusted to the subject's stature. The criteria (Table 1) reported by Steidl and Bratton (1968) were applied to the subject's anthropometric measurements and the counter height set accordingly. Then, the subject was asked if she would like the counter lower or higher for the particular task. All indicated that the adjusted counter was at a comfortable height.

TABLE 1

PREFERRED WORK SURFACE HEIGHT (INCHES) AS A FUNCTION OF ELBOW HEIGHT

Elbow Height	Beating Task	Dishwashing Task	Cutting Task
36	30	31	34.5
37	31	31.5	35
38	31	32	35.5
39	31	32.5	35.5
40	31.5	33	36
41	32	33	36.5
42	32.5	33.5	37
43	32.5	34	37

SOURCE: Steidl and Bratton, 1968.

Half the women used the 36 inch counter first and half used the adjusted counter first in an effort to remove learning bias from the experiment. The two trials for each subject were separated by at least a twenty minute resting period which appeared long enough for the physiological functions to recover from the first trial.

Each subject was asked to blend a bowl of ingredients (two eggs, one cup of flour, and one cup of water), which were slightly pre-mixed to help a uniform mixing throughout the trial. The subjects were instructed to stir the ingredients with the technique they would use in their own kitchens but make an effort to maintain a constant speed for the five minute test period. A metronome (about 115 beats per minute) was used to assist the subject in pacing herself and to insure equitable mixing speeds for each trial.

With the subject standing, heart rate was recorded using chest electrodes for five minutes prior to each trial, during the five minute trial, and for five minutes immediately following the trial. This particular experiment was expected to show significance for only the shortest women, because for the taller subjects, the "customized" counter was not much lower than the standard.

The experimental results were as expected. The three shortest subjects had a greater difference in heart rate between the two trials than the taller subjects. The average heart rate for all subjects increased ten beats per minute over the average resting level for the trial at the 36 inch counter and six beats per minute for the trial at the adjusted counter height. But the average heart rate for the shortest subjects increased fourteen and five beats per minute, respectively. In most cases the heart rate increased rapidly during the first minute or two of the work cycle and then remained relatively stable until the trial was completed. Recovery was also rapid in the first couple of minutes.

Analysis of the data was based on the increases in heart rate over resting levels (the five minute pre-trial period) as a result of the work at the different counters. When all the data were subjected to an analysis of variance, the difference in means between the two trials was significant at the 5% level. When the analysis was repeated using the data for the three shortest subjects only, significance was reached at the 2.5% level. There was no significant difference between heart rate rest levels for all subjects or the shortest subjects alone. The same was true for difference in heart rate work levels. This gives further credence to using the increase in heart rate (work over rest level) as an indicator of differences between work situations. The results, although not conclusive, indicate that the counter height does have an effect on the amount of energy expended.

Visual observations made on the subjects and the subjects' comments are also appropriate to further support the test results. The shortest subjects in particular noted that fatigue was greater while working at the standard counter. The reason for the fatigue was obvious; the shorter woman was required to mix the ingredients with her elbow well away from her torso. In two cases, the upper arm was nearly parallel to the floor. This awkward position is inefficient as the shoulder is abducted and more work is required to complete the task. The static loading on the arm is increased simply to keep the arm in the raised position. When the adjusted counter was used, the elbows were brought in close to the body with the upper arm nearly vertical.

On the other hand, the five taller subjects could not discern a difference in the counter heights. Their heart rates confirmed that a difference of two to four inches in counter height was not particularly significant in this experiment. A difference of six inches, as with the three shorter women, is significant. The only noticeable change in posture for the taller women was perhaps that a more efficient angle at the elbow joint was possible with the adjusted counter. For the mixing task, the lower arm should be 45 to 60 degrees below the horizontal with the upper arm nearly vertical; that is, the angle between the lower and upper arms should be 120-135 degrees.

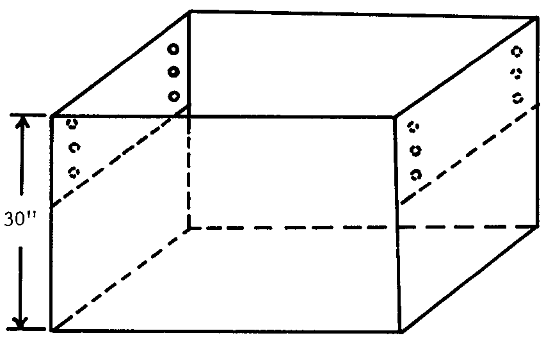
ECONOMIC ASPECTS OF ADJUSTABLE COUNTERS

Designs that have a continuous range of counter heights are desirable but have the disadvantage of high cost, because of the cost of electrical and pneumatic devices and their controls. But all that is needed to improve the design of cabinets is a simple discrete method for allowing the worker to size the kitchen to his or her stature.

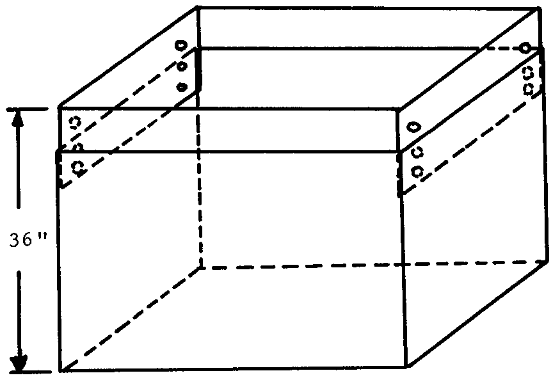
Discrete adjustment implies pre-selected increments for raising or lowering the counters. Based on Table 1, a range of 30-39 inches should be sufficient, although up to 42 inches may be desirable. In any case, increments of three inches were selected for pricing purposes. It would be a simple matter to use one or five inch increments if desired, but less than two inches would probably be an excessive number while more than four inches would tend to negate the advantages of the adjustment.

A standard base cabinet is just under 30 inches high, which gives an ideal starting point. Currently, a drawer and counter top added to the cabinet yield the 36 inch standard. To make the counter adjustable, the drawer must be eliminated, at least for the lower counter levels. This causes a problem but can be overcome by including a cabinet of drawers in each kitchen.

A rough sketch of the proposed design is shown in Figure 1. Basically, the design calls for two additional ½" by 23" by 12" panels attached to each side (inside) of the standard cabinet. The counter top is fixed to the new panels. The counter and panels are raised and lowered using pin or dowel construction. Holes drilled into the basic cabinet at three inch increments allow the counter to be raised to a specified height and the pins slipped in place to constrain the counter in the selected position. The opening in front caused by raising the counter is filled by another panel which slips in place and clips to the inside panel structure. Two front panels are needed for a



a. Base cabinet with side panels installed



b. Base cabinet with 6 inch extension in place

Figure 1--Proposed Design for Adjustable Counters (Counter Top Removed)

30-39 inch range. A three inch panel is used for a 33 inch counter height, a six inch panel for a 36 inch counter, and both the three and six inch panels for the full 39 inch counter. When not in use, these panels are attached to the inside of the cabinet to complete the self-contained unit.

A standard three foot base cabinet (just under 30 inches high) had a manufactured cost of \$23.42 (in December, 1974); the counter top costs \$15 for a total cabinet cost of \$38.42. Based on mass-production, the additional costs per counter for the adjustable design are estimated as follows: \$.92 for the two inside panels, \$.12 for pins or dowels, \$.44 for the two front panels and clips, and \$.48 additional labor. Therefore, the total additional cost is \$1.96 or an increase in the manufactured cost per cabinet of 5%. Assuming each apartment kitchen used no more than three such cabinets, the total increase wholesale cost per apartment is just under \$6.

The conclusion is that discrete adjustable counter design, such as presented in this section, is indeed cost-effective and feasible. Better overall kitchen design, which encompasses a better allocation of counter space and simple adjusting counter heights, can mean happier homemakers.

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