Indian Bread Making Tools – Correlation Between Existing and Improved Tools

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Abstract: ***Well-designed kitchen tools with ergonomic considerations help women to work comfortably, efficiently with less effort, drudgery and reduce time needed for the job. Kitchen tools include Indian bread making tools. Ergonomic research concerning industrial work situation is given priority while the work in the domestic sector also demand focus at attention as studies on chapatti making machines irrespective to household manual tools and designed and improved tools. Present study was carried out to find the correlation between the workload of women while making Indian Breads using the traditional and designed tools. Ergonomic evaluation was carried out using multi-parametric approach. Dimensions and design features were studied in terms of biomechanical, anthropometric and psychological aspects of the subject. Under object aspect, physical properties of pins and boards were analyzed. It can be concluded that the improved tools were comparatively better than that of the existing tools in the market and the households which is in confirmation with the ergonomic evaluation, user opinion evaluation and the statistical analysis of correlation made.***

Keywords: Ergonomics, Grip strength, Palm Index, Heart Rate, Energy Expenditure.

1. Introduction

The diet consciousness of people in the present days has lead to an increase in Indian bread (roti, chapatti, pulka etc.,) consumption irrespective of region (Venkatesh, 2006). The common tools used in Indian bread making are the Rolling board and Rolling pin, which are available in a variety of materials and sizes. In India these are must-haves in the kitchen. The rolling pin is used in combination with rolling board (Dua et al, 2010). A rolling pin is a cylindrical food preparation tool used to shape and flatten dough. A rolling board is an Indian kitchen tool (Heloise, 1963) which is a flat, usually circular board used for rolling kneaded dough into chapattis. Dough sticking to the pin has few disadvantages. It takes more time to complete the job and therefore is less efficient (Orlady, 2007). To prevent sticking before and during rolling, flour must be added to the dough and rubbed on the pins. This changes the texture of the dough (Manohar and Rao, 2005). When the dough sticks to the pin and needs to be removed, the weight distribution of the dough becomes inconsistent, thereby creating uneven thicknesses and therefore uneven temperature when baking, so that some parts become crisper than others. It would be desirable to develop an improved rolling pin and rolling board which avoid these disadvantages (Thomson, 1978 and Dua *et al.* 2010). As the review made, many studies were done on chapati making machines (Venkatesh, 2006), and few studies on Indian bread making tools with design flaws were found. Accordingly the Indian bread making tools were developed and the correlation between the identified and improved tools was made.

2. Materials and Methods

The purpose of present study was to carry out ergonomic evaluation on identified and developed tools used for making Indian breads and to identify the correlation between the identified and improved tools. The twin cities of Andhra Pradesh i.e. Hyderabad and Secunderabad were selected purposively as a study area due to an ever increasing number of shopping malls and attractively laid out stores, liberalisation of economy and a number of exhibitions of consumer goods has given way to several well-known brands of goods coming within the reach of the people. To standardize the procedure for ergonomic evaluation, subjective evaluation was carried out, after standardizing the procedures, a willing and cooperative six respondents was taken as the sample for case analysis. The experiments were conducted in one of the laboratories of Resource Management and Consumer Sciences, College of Home Science, Professor Jayashankar Telangana State Agricultural University, Hyderabad.

3. Results and Discussion

Under the object aspect the physical dimensional parameters like length, diameter and weight were considered of both the rolling pin and rolling board.

3.1 Product Profile

The product profile gives the complete data of the rolling pins and the rolling boards of both existing or identified tools as well as improved or developed tools. The data follows.

Table 1: Dimensions of identified rolling pins

	Model-1	*Model-2*	*Model-3*	*Model-4*	*Average*
Material	Wood	Spindle (wood)	Plastic	Curved or (wood)	
Body length (cm)	16.7	15.2	16.7	17.7	1657.5
Handle length (cm)	9.1	7.6	9.1	9.1	872.5
Total length (cm)	34.5	30.48	34.5	35.5	3374.5
Body diameter(cm)	4	4	2.5	4	362.5
Inner handle diameter(cm)	1.5	1.5	1.5	1.5	150
Outer handle diameter(cm)	1.5	3.3	1	4	245
Weight (gm)	148.2	192.8	154	171.8	16670

The table 1 depicts the physical dimension parameters of rolling pin. The body and handle dimensions of the rolling pin. It is clear from the data that the dimensions of rolling pin 1 and rolling pin 3 were almost equal in all aspects except the body diameter of the rolling pin.

Table 2: Dimensions of the identified rolling boards

	Model-1	*Model-2*	*Model-3*	*Model-4*	*Average*
Material	*Wood*	*Wood (Decolum)*	*Plastic*	*Marble*	
Diameter (cm)	25.4	24.3	24.3	24.3	2457.5
Body height (cm)	1.5	2.5	2.5	1.5	200
Base height (cm)	4	1.5	7.62	1.5	365.5
Total height (cm)	5.08	4	10.1	2.5	21.68
Weight(gm)	721.4	898	480.6	1480	89500

The table 2 depicts the physical dimensional parameters of the rolling boards. To design an appropriate hand tool, the user's hand dimensions were analyzed with the handle dimensions of the four identified rolling pins and rolling boards. The dimensions studied were length of the handle, length of the body, diameter of the handles and the body, to analyze them with the hand dimensions of the users to design appropriate tools.

Table 3: Dimensions of improved rolling pins

	Model-1	*Model-2*
Material	*Wood (light weight)*	*Wood (heavy weight)*
Body length (cm)	25.4	22.8
Handle length (cm)	10.1	10.1
Total length (cm)	45.7	43.1
Body diameter (cm)	5	5
Inner handle diameter (cm)	3.6	2.5
Outer handle diameter (cm)	5	5
Weight (gm)	168	192

The table 3 depicts the body and handle dimensions of the rolling pin. The body and handle dimensions studied were length of the handle and length of the body, distance between two handles. It is clear from the data that the dimensions of rolling pin 1 and rolling pin 2 were almost equal in all aspects except the material, body length and weight of the rolling pin

Table 4: *Dimensions of improved rolling boards*

	Model-1	Model-2	Model-3
Material	Wood (heavy weight)	Wood (light weight)	Wood (Light weight-small)
Diameter (cm)	27.9	27.9	25.4
Body thickness (cm)	2.5	2.5	2.5
Base height (cm)	2.5	2.5	2.5
Total height (cm)	5	5	5
Weight (gm)	840	750	668

The table 4 depicts the dimensions of the rolling boards. The dimensions of model 1, model 2 and model 3 were almost same except the material, diameter of body and the weight. The weight of the rolling board 3 was lowest (668 gm) compared to all other rolling boards

3.2 Correlation between Identified and Improved Tools

Correlation was done to find out the differences in performance of the existing models and the models improved by the researcher based on the suggestions and review support. The details follows.

Table 5: *Combinations of improved rolling pins and boards*

Combination models	Improved Rolling pins	Improved Rolling boards
Model 1 i	Model 1	Model 1
Model 2 i	Model 1	Model 2
Model 3 i	Model 1	Model 3
Model 4 i	Model 2	Model 1
Model 5 i	Model 2	Model 2
Model 6 i	Model 2	Model 3

(i=improved tools)*

The table 5 shows the combinations of the improved tools, for example model 1i is the combination of model 1 rolling pin and model 1 rolling board as depicted in the table 5. Likewise, the combinations of existing or identified tools are model 1 (model 1 rolling pin and model 1 rolling board), model 2 (model 2 rolling pin and model 2 rolling board), model 3 (model 3 rolling pin and model 3 rolling board), and model 4 (model 4 rolling pin and model 4 rolling board).

3.2.1. Palm Index

The data showed that, there is a positive significant difference between the existing tools and the developed. From the table 6 the greater palm was effected in the improved models of 1, 3 and 5. This was due to the increase in the diameter of the handle, as the diameter increases the effective palm area also increases which was seen from the observation of the table 6. There was 0.9 correlation between the diameter of the handle of the pin and effective palm area. In the existing tools, the greater palm area was found in the models 2 and 4. So it can be noted that the minimum requirement of handle diameter of the pin can be 4 cm and 5cm. As observed in the case of model 3, there was least diameter which could not be suggested for handling as it showed the greater variation completely from the other models. The results are in confirmation with study of Hedge and Poncers, 1995 who revealed that grip force required should get distributed to as large pressure bearing area on the palm and fingers as possible to increase the work efficiency. Whereas the length of the handle and the palm area has some correlation (0.5) which also effect the area of the palm, as the data has shown the significant difference.

Table 6: *Palm index of right hand*

Rolling pin and rolling board	*Effective palm area (cm)*	*Palm index (cm)*	*Pin handle Diameter (cm)*	*Length of the pin (cm)*	*Palm index (%)*
Model 3	81.9	0.08	1	9.1	8.15
Model 4	36.4	0.18	4	9.1	18.79
Model 1i	36.36	0.20	3.6	10.1	20.54
Model 3i	36.36	0.20	3.6	10.1	20.54
Model 5i	36.36	0.20	3.6	10.1	20.54
Model 2i	25.25	0.16	2.5	10.1	16.24
Model 4i	25.25	0.16	2.5	10.1	16.24
Model 6i	25.25	0.16	2.5	10.1	16.24
Model 2	22.8	0.18	3	9.6	18.54
Model 1	22.75	0.14	1.5	9.1	14.24

(i=improved tools)*

Correlation,
Length of the pin X Effective palm area =0.5
Diameter handle diameter X Effective palm area =0.8
Palm index X Effective palm area= 0.5

From this, it can be statistically proved that the improved tools had better efficiency when compared to the identified tools due to the increase in the length and diameter of the handle of rolling pin. When compared to the length of the handle, diameter of the handle and effective palm area, diameter of the handle played a major role in the effect of palm area i.e, the diameter has shown more significant difference than length and palm area. As the tool was plastic (model 3) there is a great variation in the correlation.

Table 7: Palm Index of left hand

Rolling pin and board	*Effective palm area (cm)*	*Palm index (cm)*	*Pin handle Diameter (cm)*	*Length of pin (cm)*	*Palm index (%)*
Model 3	81.9	0.06	1	9.1	6.05
Model 4	36.4	0.17	4	9.1	17.54
Model 1	36.36	0.18	3.6	10.1	18.79
Model 3i	36.36	0.14	3.6	10.1	14.11
Model 5i	36.36	0.14	3.6	10.1	14.11
Model 2i	25.25	0.14	2.5	10.1	14.11
Model 4i	25.25	0.18	2.5	10.1	18.54
Model 6i	25.25	0.18	2.5	10.1	18.79
Model 2	22.8	0.18	3	9.6	18.79
Model 1	22.75	0.14	1.5	9.1	14.11

(i=improved tools)*

Correlation,
Length of the pin X Effective palm area =0.5
Diameter handle diameter X Effective palm area =0.8
Palm index X Effective palm area= 0.5

The data showed that, there is a positive significant difference between the existing tools and the developed. From table 7, palm was effected greater in improved models of 1, 3 and 5. This was due to the increase in the diameter of the handle, as the diameter increases the effective palm area also increases which was seen from the observation of the table 7. In the existing tools, the greater palm area was found in the models 2 and 4. So it can be noted that the minimum requirement of handle diameter of the pin can be 4 cm and 5cm but not below this level of consideration. As observed in the case of model 3, there was least diameter which could not be suggested for handling as it showed the greater variation completely from the other models. The results are in confirmation with study of Hedge and Poncers, 1995 who revealed that grip force required should get distributed to as large pressure bearing area on the palm and fingers as possible to increase the work efficiency. Whereas the length of the handle and the palm area has some correlation (0.5) which also effect the area of the palm, as the data has shown the significant difference. Due to the counter balancers provided to the improved tools, there is only a slight variation in the right and left hands. This is confirmation with Chakrabarti (1997) who revealed that, there is anthropometric difference between the right and left hands where the counter balance of the tool with appropriate grip has effective use. By this, it can be statistically proved that the improved tools has better efficiency when compared to the existing tools due to the increase in the length and diameter of the handle of rolling pin. Compared to length of handle, diameter of handle and effective palm area, diameter of handle played a major role in the effect of palm area i.e., diameter has shown more significant difference than length and palm area.

3.2.2 Grip strength

The table 8 shows that reduction of grip strength of identified tools was more while using model 3 and model 2 and model 4, when compared to use of model 1. It can also be noted that the reduction in grip strength of right hand while using model 3 was more followed by model 2 and model 1. This is due to the grip of the handle of the pin, shape of the board. The reduction in grip strength while using model 4 was found to be less. This indicates that the deviation of the wrist is more for model 3 which reduced the grip strength.

Table 8: Grip strength of right hand

Rolling pin and board	*Before work (kilograms)*	*After work (kilograms)*
Model 1	31.84	24.32
Model 2	32.21	26.84
Model 3	42.2	20.12
Model 4	29.15	22.79
Model 1 i	23.31	20.61
Model 2 i	24.05	22.15
Model 3 i	28.56	24.98
Model 4 i	32	29.61
Model 5 i	40.58	38.15
Model 6 i	32	32

(i=improved tools)*

Correlation-Before and after work-0.7

The results (table 8) of developed tools are depicted that the reduction of grip strength was more while using model 1 and model 4 when compared to the use of model 6, model 2, model 3 and model 5. It can also be noted that the reduction in grip strength of right hand while using model 1 and model 4 was more followed by model 5, model 2 and model 3. The reduction in grip strength while using model 6 was found to be less. It may be due to the dimensional aspects of the pin, as the pin is of greater dimensions with 5 cm circumference and due to the light weight material (teak wood) with the silicone finish. As the correlation value is 0.7, there is significant difference between the existing tools and developed tools. The result is in confirmation with the research conducted by Rempel *et al.* 1994., Rempel and Horie, 1994 which showed that hand movements affect interstitial fluid pressure within the carpal tunnel, and any pressure increase can compress the median nerve and other structures. Pressure changes within the carpal tunnel show a curvilinear relationship. As the force applied on the handle of the tool, the force exertion changes due to the shape, grip, stability. If the weight of the tool is more force has to be applied to roll the dough where the stress on the carpal tunnel, muscle and fore arm falls and leads to the fatigue. This is in confirmation with study by Gibran and Frith (2001) who showed that non-stick feature and proper grip of bread making tool, helps in increasing the efficiency of the tool.

Table 9: Grip strength of left hand

Rolling pin and rolling board	*Before work (kilograms)*	*After work (kilograms)*
Model 1	25.98	20.78
Model 2	38.25	30.29
Model 3	42.2	20.12
Model 4	29.15	21.79
Model 1 i	23.31	19.61
Model 2 i	24.05	20.15
Model 3 i	28.56	26.98
Model 4 i	32	30.61
Model 5 i	40.58	38.15
Model 6 i	32	32

(i=improved tools)*

Correlation-Before and after work-0.5

The results (table 9) of existing tools show that the reduction of grip strength was more while using model 3 and model 2 and model 4, when compared to the use of model 1. It can also be noted that the reduction in grip strength of right hand while using model 3 was more followed by model 2 and model 1. This is due to the grip of the handle of the pin, shape of the board. The reduction in grip strength while using model 4 was found to be less. This indicates that the deviation of the wrist is more for model 3 which reduced the grip strength. The results of developed tools are depicted that the reduction of grip strength was more while using model 1 and model 4 when compared to the use of model 6, model 2, model 3 and model 5. It can also be noted that the reduction in grip strength of right hand while using model 1 and model 4 was more followed by model 5, model 2 and model 3. The reduction in grip strength while using model 6 was found to be less. It may be due to the dimensional aspects of the pin, as the pin is of greater dimensions with 5 cm circumference and due to the light weight material (teak wood) with the silicone finish. As the correlation value is 0.5, there is significant difference between the existing tools and developed tools. The result is in confirmation with the research conducted by Rempel *et al.* 1994., Rempel and Horie, 1994 which showed that hand movements affect interstitial fluid pressure within the carpal tunnel, and any pressure increase can compress the median nerve and other structures. Pressure changes within the carpal tunnel show a curvilinear relationship. As the force applied on the handle of the tool, the force exertion changes due to the shape, grip, stability. If the weight of the tool is more force has to be applied to roll the dough where the stress on the carpal tunnel, muscle and fore arm falls and leads to the fatigue. This is in confirmation with study by Gibran and Frith (2001) who showed that non-stick feature and proper grip of bread making tool, helps in increasing the efficiency of the tool.

3.2.3 Heart Rate (10 count method)

The heart rate of existing tools was more when compared to the developed tools. As the more force applied on the tools force had to be applied on the muscle and carry on work which increases the heart rate. It is also proved statistically from table 10, that as the correlation is 0.5, there is a significant difference between the existing and developed models. This shows that the developed tools are better comparatively to the existing ones. As the developed tools are of greater dimensions with the counter balancers, made the rolling easily without any stress and fatigue.

Table 10: Heart rate ($b.min^{-1}$)

Rolling pin and rolling board	*Heart rate at rest*	*Heart rate at work*
Model 1	60 .86	91.86
Model 2	99.28	119.28
Model 3	48.2	58.2
Model 4	77.26	97.26
Model 1 i	82.58	92.58
Model 2 i	58.7	62.7
Model 3 i	56.7	62.7
Model 4 i	89.58	92.58
Model 5 i	69.02	70.02
Model 6 i	48.76	50.76

(i=improved tools)*

Correlation-0.5

In the present study the increase in heart rate while using model 1 and 4 is higher. The difference of heart rate was less pronounced using model 6. While using model 1 and 4 the deviation from the neutral posture is more resulting in increase of physical stress as the boards are of light weight and more force had been exerted on the pins to roll the dough. While rolling dough, there is minimum of heart rate for model 6, where the board is stable and the light weight pin and mainly the length of the body of pin and diameter of the board are equal which helps in rolling easily with to and fro strokes. The results are in accordance with the study by Kroemer and Grandjean (1997) who mentioned that the heart rate increases linearly with the work performed, provided it is dynamic, not static and is performed with a steady rhythm and is influenced by the posture adopted, force applied and the type of product. The correlation between the before work and after work of heart rate was correlated and was found that there is positive correlation between the heart rate and energy expenditure of 0.5. It can be concluded that, the improved tools had better efficiency to the existing or identified tools.

3.2.4 Energy expenditure

Energy consumption was usually the means by which the severity of physical stress was estimated but it is evident that energy consumption alone may not be a sufficient measure. The degree of physical stress not only depends on the number of kilojoules consumed but also on the number of muscles involved and on the extent to which they are under static load. The same energy consumption by static muscular effort is distinctly more tiring than if it is applied to dynamic work. It is evident that work at a given energy consumption can make different demands on the heart. The energy consumption of existing tools was more when compared to the developed tools, which may be due to the severity of physical stress on the tools. As heart rate increases energy consumption pronounces in increase. It is also proved statistically from table 11 that as the correlation value is 0.8; there is significant difference of energy consumption between the existing and developed models.

Table 11: Difference in Energy expenditure (Kilo joules)

Rolling pin and board	*Energy expenditure*
Model 1	13.0
Model 2	14.6
Model 3	17.5
Model 4	16.9
Model 1 i	11.65
Model 2 i	8.17
Model 3 i	6.17
Model 4 i	10.28
Model 5 i	6.28
Model 6 i	4.15

(i=improved tools)*

This shows that the developed tools are better comparatively to the existing ones. As the developed tools are of greater dimensions with the counter balancers, made the rolling easily without any physical stress and fatigue. The correlation between the heart rate and energy expenditure was found that there is positive correlation between the heart rate and energy expenditure of 0.8. The grip strength was also correlated and found that (0.6) there is a correlation between the grip and energy expenditure. As the force applied is more the energy expenditure is also increased. It can be concluded that, the improved tools had better efficiency to the existing tools.

4. Conclusion

It can be concluded that, the improved tools had better efficiency to the existing tools. The improved tools were comparatively better than that of the existing tools in the market and the households which is in confirmation with the ergonomic evaluation, user opinion evaluation and the statistical analysis of correlation made. The users felt comfortable while using the improved tools of rolling pin in the aspects of grip of handle, length of the handle, diameter and length of the body of pin and also the non-stick finish of the tool, whereas in the case of rolling boards- the stability of the boards, the silicon (non-stick) coated finish were very comfortable for the users while rolling.

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