

# Foot Anthropometry of Primary School Children in the South of Thailand

S. Rawangwong, J. Chatthong, and W. Boonchouytan

**Abstract**—The objective of the research was to study of foot anthropometry of children aged 7-12 years in the South of Thailand. Thirty-three dimensions were measured on 305 male and 295 female subjects with 3 age ranges (7-12 years old). The instrumentation consists of four types of anthropometer, digital vernier caliper, digital height gauge and measuring tape. The mean values and standard deviations of average age, height, and weight of the male subjects were 9.52(±1.70) years, 137.80(±11.55) cm, and 37.57(±11.65) kg. Female average age, height, and weight subjects were 9.53(±1.70) years, 137.88(±11.55) cm, and 34.90(±11.57) kg respectively. The comparison of the 33 comparison measured anthropometric. Between male and female subjects were sexual differences in size on women in almost all areas of significance ( $p < 0.05$ ). The comparison of size and proportion elementary school students 11-12 years old men in Southern of Thailand with Thai boys aged 11-12 years of industrial standards at stage 4 year A.D. 2000-2001 Number nine ratio. Concluded that students male in Southern of Thailand has a size different from the proportions of research Industrial Standards. Ministry of Industry, Phase 4, when every year from A.D. 2000-2001 ratio was significantly ( $p < 0.05$ ). All of the feet studied were classified into 4 categories according to the ratios of diagonal foot breadth to the maximum foot length and heel breadth to the foot breadth. They were short but thick, small but long, small, and large. The numbers of the males feet classified in these categories were 86, 64, 40, and 115 persons or 28.20, 20.98, 13.11, and 37.70% respectively. For the female feet, the same values were 46, 59, 81, and 109 persons or 15.59, 20.00, 27.46, and 36.95% respectively.

**Keywords**—Ergonomics, foot anthropometry, male and female, primary school children

## I. INTRODUCTION

ANTHROPOMETRY consists on the measurement of body dimensions such as reach, length, width and heights. This information can be used to design tools, equipment, work stations and clothes. Appropriate use of anthropometry in design may improve well-being, health, comfort and safety [1-8]. Shoes are the important equipments that are essential need for people. For suitable design of shoes, foot dimensions of consumers are required. Length, widths and heights of feet should match with shoes in order for footwear to be comfortable [3]. There are many studies on foot anthropometry to use in sizing foot, making shoe last and determining the correlation between the foot dimensions [9-17]. A study was done about foot anthropometry in Hong Kong. Even though, numerous devices are available for measuring the foot.

S. Rawangwong is with the Department of Industrial Engineering, Rajamangala University of Technology Srivijaya, Songkhla, CO 90000, Thailand (phone: 087-291-2560; e-mail: sitnong2@yahoo.co.th).

J. Chatthong is with the Department of Industrial Engineering, Rajamangala University of Technology Srivijaya, Songkhla, CO 90000, Thailand (phone: 080-540-4848; e-mail: jaknarin\_c@hotmail.com).

W. Boonchouytan is with the Department of Industrial Engineering, Rajamangala University of Technology Srivijaya, Songkhla, CO 90000, Thailand (phone: 081-569-7303; e-mail: b\_ieeng@hotmail.com).

Generally, only one or two dimensions are used when sizing a foot. The study attempts to find orthogonal dimensions so that a Hong Kong Chinese to may be properly sized and modeled. Factor analysis and principal component analysis indicated that the height dimension is important. Hence, it is recommended that at least two dimensions be measured in the forefoot, mid foot and rear foot to model the foot better [17].

At the present, the shoes are playing more important role not only for beauty wearing but also safety is a crucial factor in designing. Therefore, designing size on the foot anthropometry is necessary process of shoe production [18]. There are various researches investigating on the foot anthropometry designing but the foot anthropometry for the Southern children in Thailand still lacks of standard which can support the foot growth in primary level students. Up to now there has not been any special foot anthropometry in Thailand. While this is one of the important problems of shoe designers and makers in this country. So, they ought to use anthropometric data's of other nations in designing and sizing the shoes.

The instrument and equipment were designed as practical as other everyday tools for collecting the data of the foot anthropometry. After that, the data was analyzed by using ergonomics in order to design other more practical instruments. Therefore, the main aim of this research study was to survey the foot anthropometry of primary provincial school students in the South of Thailand for foot product development.

## II. METHODOLOGY

This survey research was to collect the foot anthropometry of 600 subjects; 305 males and 295 females from primary provincial school students in the South of Thailand at the age of 7-12 years. Then, the data was compared to the differences of foot size for each sex. (Ministry of Industry, Phase 4, when every year from A.D. 2000 to 2001 ratio) [19].

- 1) The foot anthropometry of 600 subjects; 305 males and 295 females from primary provincial school students in the South of Thailand at the age of 7-12 years with normal foot size.
- 2) A The sampling group was male and female from 14 primary provincial school students in the South of Thailand and all data collection was recorded in the foot anthropometry format designed by International Organization for Standardization, ISO e.g. ISO 7250: 2004; Basic Human Body Measurements for Technological Design [20], US-(MIL-STD) Japan-(JIS Z 8500: 2002) [21] and German-DIN 1978. Moreover, the measurement was done during the staff standing foot (Static dimensions) with three times and the data was analyzed for mean and percentile; 1, 5, 50, 95 and 99 [22], [23]. There were 33 measurement positions as following; 1) foot circumference 2) instep circumference 3) heel circumference 4) diagonal

ankle circumference 5) bimalleolar circumference 6) ankle circumference 7) foot length 8) foot length 9) foot length: heel to tip little toe 10) fibular instep length 11) foot breadth 12) instep length 13) bimalleolar breadth 14) heel breadth 15) foot breadth, diagonal 16) first toe length 17) second toe length on of first toe 18) second toe length on side of third toe 19) second toe length on side of second toe 20) second toe length on side of fourth toe 21) third toe length on side of fourth toe 22) fourth toe length on side of third toe 23) fifth toe length on of fourth toe 24) great toe tip height 25) great toe height 26) ball height 27) dorsal arch height 28) foot height 29) sphyrion height 30) medial mallcolar height 31) outside ball height 32) sphyrion fibulare height 33) lateral malleolus height.

- 3) The allocated positions of the foot anthropometry for reliability and accuracy by lib liner which has 9 positions as following: 1) joints of the bones of a toe 2) metatarsal cunciform joint (tarsomctatarsal joint) 3) midfoot 4) metatarsale tibiale 5) sphyrion 6) medial mallcolus 7) metatarsale fibulare 8) sphyrion fibulare 9) lateral mallcolus (JIS, 2002) (ISO 7250, 2004) (Human Systems Information Analysis Center, 1994).
- 4) The instrument and equipment were conducted in collecting data of foot anthropometry consisted of 1) Measuring tape 2) Digital vernier caliper 3) Digital height gauge 4) Caliper 5) Adjective chairs 6) Weight scale as shown in the Fig. 1

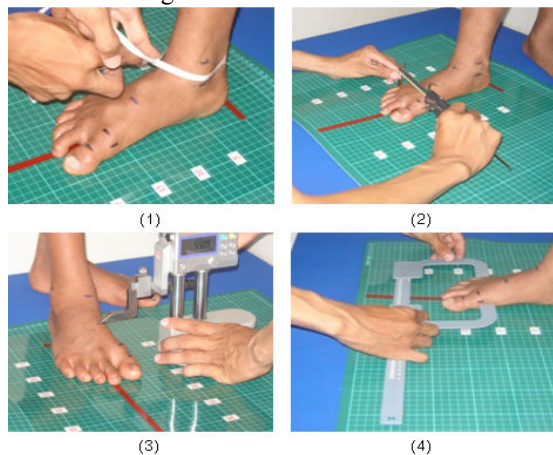


Fig. 1 Various measurement instruments 1) Measuring tape  
2) Digital vernier caliper 3) Digital height gauge  
4) Caliper

### III. RESULTS

The measurement of the foot anthropometry of 600 subjects; 305 males and 295 females from primary provincial school students in the South of Thailand by using various kinds of measurement instruments, there were 33 proportions of foot size measurements. The data was analyzed by means, standard deviations, and percentile was at 1, 5, 50, 95 and 99 [22], [23]. This data analysis was used to compare the foot size of the primary school students. In addition, the results of the study was to survey the structure of Thai foot size with phrase 4 A.D 2000-2001 (by Office of Industrial Standard,

Ministry of Industry) [19]. The statistic of Z-test was applied in this treatment and it had also the reliability at 95 % as following details;

#### • The Results of the foot anthropometry of male primary provincial school students in the South of Thailand

The findings of measurement of the foot anthropometry of 305 male students from primary provincial school in the South of Thailand presented in Table I and the measurement of the foot anthropometry 295 female students from primary provincial school in the South of Thailand presented in Table II.

TABLE I  
THE MEANS, STANDARD DEVIATIONS AND PERCENTILE AT 1, 5, 50, 95 AND 99 OF MEASUREMENT OF THE FOOT ANTHROPOMETRY OF 305 MALES WITH THE AGE OF 7-12 YEARS FROM PRIMARY PROVINCIAL SCHOOL STUDENTS IN THE SOUTH OF THAILAND (UNIT: MILLIMETER)

Proportion Items	Mean	SD	percentiles				
			1 % Tile	5 % Tile	50 % Tile	95 % Tile	99 % Tile
1. Foot Circumference	211.09	17.50	180.00	185.00	210.00	240.00	255.00
2. Instep Circumference	240.43	21.21	195.14	204.28	240.00	275.00	285.97
3. Heel Circumference	267.43	25.25	220.00	230.00	265.50	300.08	349.97
4. Diagonal Ankle Circumference	272.50	19.18	235.00	240.06	271.00	300.80	319.85
5. Bimalleolar Circumference	225.46	19.79	184.04	195.00	225.00	255.00	274.85
6. Ankle Circumference	196.31	17.10	165.00	170.00	195.00	225.00	235.00
7. Foot Length	213.25	17.85	175.00	185.00	210.00	245.00	254.94
8. Foot Length	212.10	17.82	175.00	185.00	210.01	241.00	254.87
9. Foot Length : Heel to Tip of Little Toe	167.27	13.52	143.00	146.00	165.00	190.00	195.00
10. Fibular Instep Length	150.70	14.60	120.00	126.40	150.00	178.84	184.91
11. Foot Breadth	87.16	8.69	70.00	75.00	85.60	100.00	110.00
12. Instep Length	164.30	14.17	139.04	143.14	165.00	185.80	195.00
13. Bimalleolar Breadth	62.07	6.33	45.18	50.22	60.50	74.40	75.00
14. Heel Breadth	52.21	5.85	40.00	40.50	51.00	65.00	65.00
15. Foot Breadth, Diagonal	90.16	8.72	69.22	78.35	89.17	105.12	113.94
16. First Toe Length	36.46	4.64	25.27	27.87	36.70	45.05	47.63
17. Second Toe Length on Side of First Toe	36.59	4.55	26.83	28.83	36.59	44.07	47.61
18. Second Toe Length on Side of Third Toe	33.17	4.49	23.56	26.66	33.25	39.89	44.92
19. Third Toe Length on Side of Second Toe	28.67	3.76	21.46	23.56	28.38	35.29	38.71
20. Third Toe Length on Side of Fourth Toe	32.41	5.10	21.42	23.83	32.84	39.02	43.41
21. Fourth Toe Length on Side of Third Toe	25.16	3.89	18.26	20.06	24.72	33.62	35.27
22. Fourth Toe Length on Side of Fifth Toe	33.43	5.44	19.87	23.54	33.91	41.85	48.54
23. Fifth Toe Length on Side of Fourth Toe	22.31	3.68	14.19	16.14	21.92	28.35	34.44
24. Great Toe Tip Height	19.54	2.63	13.46	16.09	19.21	23.71	25.79
25. Great Toe Height	24.51	3.01	15.38	19.69	24.30	29.25	32.12

TABLE I (CONTINUED)

Proportion Items	Mean	SD	percentiles				
			1 % Tile	5 % Tile	50 % Tile	95 % Tile	99 % Tile
26. Ball Height	32.55	3.60	23.94	27.14	32.35	39.23	40.80
27. Dorsal Arch Height	49.58	5.11	35.13	41.42	49.86	58.43	62.16
28. Foot Height	67.77	6.43	54.28	57.79	67.69	77.96	81.73
29. Sphyrion Height	61.33	7.27	40.70	50.50	61.35	73.25	77.53
30. Medial Malleolar Height	79.20	7.15	62.80	67.98	78.88	91.21	99.03
31. Outside Ball Height	23.60	3.26	16.44	18.59	23.82	28.59	31.81
32. Sphyrion Fibulare Height	48.16	7.28	21.76	37.42	48.33	61.46	67.19
33. Lateral Malleolus Height	69.88	7.00	56.00	60.17	68.87	81.23	87.25

TABLE II

THE MEANS, STANDARD DEVIATIONS AND PERCENTILE AT 1, 5, 50, 95 AND 99 OF MEASUREMENT OF THE FOOT ANTHROPOMETRY OF 295 FEMALE WITH THE AGE OF 7-12 YEARS FROM PRIMARY PROVINCIAL SCHOOL STUDENTS IN THE SOUTH OF THAILAND (UNIT: MILLIMETER)

Proportion Items	Mean	SD	percentiles				
			1 % Tile	5 % Tile	50 % Tile	95 % Tile	99 % Tile
1. Foot Circumference	199.33	14.81	170.00	175.35	200.00	225.00	235.00
2. Instep Circumference	228.03	18.77	190.00	202.31	225.00	260.00	280.00
3. Heel Circumference	258.38	18.51	219.99	225.00	260.00	290.00	300.09
4. Diagonal Ankle Circumference	266.93	17.03	220.00	240.00	270.00	290.00	301.54
5. Bimallolar Circumference	211.79	16.81	170.00	180.00	215.00	235.00	250.00
6. Ankle Circumference	187.79	15.63	150.47	161.76	185.00	215.00	221.24
7. Foot Length	212.04	15.48	170.00	185.35	215.00	235.00	245.00
8. Foot Length	213.50	15.48	170.09	185.00	215.00	235.00	245.01
9. Foot Length : Heel to Tip of Little Toe	165.82	13.80	130.00	142.25	165.00	186.40	195.12
10. Fibular Instep Length	151.26	13.11	120.09	130.00	150.00	174.11	181.24
11. Foot Breadth	83.81	7.53	65.94	70.38	85.00	95.00	100.00
12. Instep Length	163.37	13.05	133.00	140.00	165.00	181.68	190.00
13. Bimalleolar Breadth	266.93	17.03	45.75	50.00	60.00	70.00	80.00
14. Heel Breadth	50.32	5.53	40.00	40.00	50.00	60.00	65.00
15. Foot Breadth, Diagonal	86.55	6.50	70.72	75.22	87.52	95.98	101.56
16. First Toe Length	36.65	3.82	27.70	30.36	36.66	42.01	46.30
17. Second Toe Length on Side of First Toe	36.52	3.91	28.47	30.32	36.33	42.37	46.77
18. Second Toe Length on Side of Third Toe	33.21	4.05	23.26	26.30	33.47	39.22	40.25
19. Third Toe Length on Side of Second Toe	29.11	4.95	20.43	23.15	28.89	36.05	39.90
20. Third Toe Length on Side of Fourth Toe	31.23	4.81	20.93	22.13	31.62	37.96	41.71
21. Fourth Toe Length on Side of Third Toe	26.10	4.29	18.37	19.71	25.85	34.89	39.28
22. Fourth Toe Length on Side of Fifth Toe	32.68	5.02	18.84	21.09	33.29	40.11	42.13
23. Fifth Toe Length on Side of Fourth Toe	22.53	2.92	16.84	18.13	22.32	28.02	29.36
24. Great Toe Tip Height	18.19	1.88	13.35	15.10	18.17	21.45	22.70
25. Great Toe Height	23.58	2.52	18.15	19.55	23.48	27.94	30.51
26. Ball Height	31.41	3.83	23.67	26.86	31.08	36.13	50.75
27. Dorsal Arch Height	48.29	4.82	38.46	41.98	47.60	57.16	59.03
28. Foot Height	65.61	5.82	51.20	55.68	65.80	73.36	78.43
29. Sphyrion Height	61.02	6.67	47.95	51.04	60.97	71.23	77.38
30. Medial Malleolar Height	77.11	7.44	61.52	65.12	76.60	88.66	91.01
31. Outside Ball Height	23.16	3.16	15.46	17.63	23.39	27.98	28.43
32. Sphyrion Fibulare Height	46.45	5.51	33.46	35.42	46.91	54.40	55.76
33. Lateral Malleolus Height	66.90	7.03	48.58	55.61	66.92	79.54	81.43

TABLE III

THE COMPARISON OF THE FOOT ANTHROPOMETRY BETWEEN MALE AND FEMALE STUDENTS WITH THE AGE OF 7-12 YEARS FROM PRIMARY PROVINCIAL SCHOOL IN THE SOUTH OF THAILAND

Proportion items	Male students (n=305)		Female students (n=295)		Z-test	Result
	Mean	SD	Mean	SD		
1. Foot Circumference	211.09	17.50	199.33	14.81	8.90	HS
2. Instep Circumference	240.43	21.21	228.03	18.77	7.59	HS
3. Heel Circumference	267.43	25.25	258.38	18.51	5.02	HS
4. Diagonal Ankle Circumference	272.50	19.18	266.93	17.03	3.76	HS
5. Bimallolar Circumference	225.46	19.79	211.79	16.81	9.13	HS
6. Ankle Circumference	196.31	17.10	187.79	15.63	6.37	HS
7. Foot Length	213.25	17.85	212.04	15.48	0.89	NS
8. Foot Length	212.10	17.82	213.50	15.48	-1.02	NS
9. Foot Length : Heel to Tip of Little Toe	167.27	13.52	165.82	13.80	1.30	NS
10. Fibular Instep Length	150.70	14.60	151.26	13.11	-0.49	NS
11. Foot Breadth	87.16	8.69	83.81	7.53	5.06	HS
12. Instep Length	164.30	14.17	163.37	13.05	0.84	NS
13. Bimalleolar Breadth	272.50	19.18	266.93	17.03	3.76	HS
14. Heel Breadth	52.21	5.85	50.32	5.53	-0.86	NS
15. Foot Breadth, Diagonal	90.16	8.72	86.55	6.50	1.31	NS
16. First Toe Length	36.46	4.64	36.65	3.82	1.54	NS
17. Second Toe Length on Side of First Toe	36.59	4.55	36.52	3.91	3.17	HS
18. Second Toe Length on Side of Third Toe	33.17	4.49	33.21	4.05	3.42	HS
19. Third Toe Length on Side of Second Toe	28.67	3.76	29.11	4.95	1.09	NS
20. Third Toe Length on Side of Fourth Toe	32.41	5.10	31.23	4.81	3.16	HS
21. Fourth Toe Length on Side of Third Toe	25.16	3.89	26.10	4.29	2.28	S
22. Fourth Toe Length on Side of Fifth Toe	33.43	5.44	32.68	5.02	1.20	NS
23. Fifth Toe Length on Side of Fourth Toe	22.31	3.68	22.53	2.92	3.86	HS
24. Great Toe Tip Height	19.54	2.63	18.19	1.88	2.55	S
25. Great Toe Height	24.51	3.01	23.58	2.52	1.17	NS
26. Ball Height	32.55	3.60	31.41	3.83	5.84	HS
27. Dorsal Arch Height	49.58	5.11	48.29	4.82	3.19	HS
28. Foot Height	67.77	6.43	65.61	5.82	4.33	HS
29. Sphyrion Height	61.33	7.27	61.02	6.67	0.53	NS
30. Medial Malleolar Height	79.20	7.15	77.11	7.44	3.50	HS
31. Outside Ball Height	23.60	3.26	23.16	3.16	1.69	NS
32. Sphyrion Fibulare Height	48.16	7.28	46.45	5.51	3.25	HS
33. Lateral Malleolus Height	69.88	7.00	66.90	7.03	5.19	HS

Remarks HS : Highly Significant  
S : Significant (p<0.05)  
NS : Not Significant

- *The comparison between male and female students foot anthropometry from primary provincial school in the South of Thailand*

The comparison of the foot anthropometry between male and female students with the age of 7-12 from primary provincial school in the South of Thailand was shown in Table III. The measurement proportion was 33 items. The means, standard deviations were analyzed by using Z-test with 0.5 significant.

- *The comparison of the subject foot size proportion between this research and other research in Thailand*

The comparison of the subject foot anthropometry with the age of 7-12 from primary provincial school students in the South of Thailand and the survey research of Thai foot structures in Phase 4 A.D. 2000-2001 (by the Office of Industrial Standard, Ministry of Industry) was illustrated in Table IV and V. By indicating means, standard deviation of 9 foot anthropometry proportion items, the Z-test with significant 0.05 was tried out for differences of means.

TABLE IV

THE COMPARISON OF THE MALE SUBJECTS FOOT ANTHROPOMETRY WITH THE AGE OF 7-12 YEARS FROM PRIMARY PROVINCIAL SCHOOL STUDENTS IN THE SOUTH OF THAILAND AND THE SURVEY RESEARCH OF THAI FOOT STRUCTURES BY THE OFFICE OF INDUSTRIAL STANDARD, MINISTRY OF INDUSTRY IN PHASE 4 A.D. 2000-2001

Proportion items	Male students (n=305)		Female Students (n=295)		Z-test	Results
	Mean	SD	Mean	SD		
1. Foot Circumference	211.09	17.50	205.33	17.00	5.42	HS
2. Instep Circumference	240.43	21.21	205.00	17.00	28.02	HS
3. Diagonal Ankle Circumference	272.50	19.18	276.83	24.67	-3.58	HS
4. Bimallcolar Circumference	225.46	19.79	184.83	21.83	33.30	HS
5. Foot Length	212.10	17.82	210.50	14.00	1.51	NS
6. Foot Length : Heel to Tip of Little Toe	167.27	13.52	145.00	10.67	27.66	HS
7. Foot Breadth	87.16	8.69	86.17	8.50	1.88	NS
8. Heel Breadth	52.21	5.85	50.67	5.50	4.37	HS
9. Sphyrion Fibulare Height	48.16	7.28	46.17	6.00	4.58	HS

TABLE V

THE COMPARISON OF THE FEMALE SUBJECTS FOOT ANTHROPOMETRY WITH THE AGE OF 7-12 YEARS FROM PRIMARY PROVINCIAL SCHOOL STUDENTS IN THE SOUTH OF THAILAND AND THE SURVEY RESEARCH OF THAI FOOT STRUCTURES BY THE OFFICE OF INDUSTRIAL STANDARD, MINISTRY OF INDUSTRY IN PHASE 4 A.D. 2000-2001

Proportion items	Male students (n=305)		Female Students (n=295)		Z-test	Results
	Mean	SD	Mean	SD		
1. Foot Circumference	199.33	14.81	200.50	14.00	-1.28	NS
2. Instep Circumference	228.03	18.77	198.17	13.33	26.50	HS
3. Diagonal Ankle Circumference	266.93	17.03	269.33	20.50	-2.23	S
4. Bimallcolar Circumference	211.79	16.81	180.17	18.17	30.16	HS
5. Foot Length	213.50	15.48	208.83	12.83	4.96	HS
6. Foot Length : Heel to Tip of Little Toe	165.82	13.80	142.50	9.17	28.24	HS
7. Foot Breadth	83.81	7.53	82.83	6.67	2.12	S
8. Heel Breadth	50.32	5.53	49.67	4.17	1.95	NS
9. Sphyrion Fibulare Height	46.45	5.51	46.33	5.33	0.35	NS

• *Patterns of foot types*

According to the researcher results, the subject foot size from primary provincial school students in the South of Thailand could be categorized into 4 main pattern types and it could be claimed in terms of percentage as shown in Table VI.

TABLE VI  
THE FREQUENCY AND PERCENTAGE OF THE SUBJECTS FOOT TYPES

Foot Types	Males		Females	
	Frequency	Percentage	Frequency	Percentage
Pattern A	86.00	28.20	46.00	15.59
Pattern B	64.00	20.98	59.00	20.00
Pattern C	40.00	13.11	81.00	27.46
Pattern D	115.00	37.70	109.00	36.95
Total	305.00	100.00	209.00	100.00

The figuring out of foot size proportion calculated by using 4 proportion items like 1) maximum foot length 2) foot breadth diagonal 3) foot breadth and 4) heel breadth as shown in Fig. 2 [7] and formula 1 and 2 were used to find out foot shape.

*Width of foot breath diagonal*

$$\text{Formula 1} = \frac{\text{Foot Breadth Diagonal}}{\text{Maximum Foot Length}} \times 100\% \quad (1)$$

*Width of heel breath*

$$\text{Formula 2} = \frac{\text{Heel Breadth}}{\text{Foot Breadth}} \times 100\% \quad (2)$$

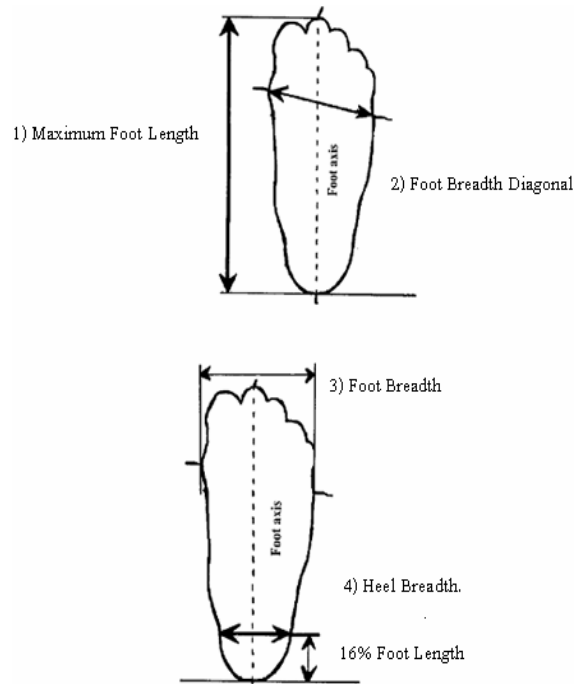


Fig. 2 Basic size proportion used for calculation

Patterns A, the foot type was characterized as circular and widens foot breath and short. It is called as circular foot shape. The findings revealed that the male subjects had long foot breath proportion at 0.42 less than 0.60 and the female subjects had long foot breath proportion at 0.41 less than 0.60 respectively.

Patterns B, the foot type was characterized as long and narrowed foot axis. It is called as long foot shape. The data revealed that the male subjects had widen foot breath proportion at 0.33 less than 0.55 and the female subjects had widen foot breath proportion at 0.41 less than 0.55 respectively. Patterns C, the foot type was characterized as narrowed foot breath and short. It is called as small foot shape. The findings revealed that the male subjects had widen foot breath diagonal proportion at 0.43 less than 0.63 and the female subjects had widen foot breath diagonal proportion at 0.43 less than 0.63 respectively. Patterns D, the foot type was characterized as widen foot breath and long heel breath. It is called as big foot shape. The data revealed that the male subjects had widen foot breath proportion at 0.43 less than 0.65 and the female subjects had widen foot breath proportion at 0.43 less than 0.65 respectively.



Fig. 3 Characteristic of 4 pattern foot types

#### IV. CONCLUSION

According to the research findings in this study, the measurement proportion of the foot anthropometry of 600 subjects; 305 males with age of  $9.52(\pm 1.70)$  yrs, height of  $137.80(\pm 11.55)$  cm, and weight of  $37.57(\pm 11.65)$  kg; whereas, 295 females with age of  $9.53(\pm 1.70)$  yrs, height of  $137.88(\pm 11.55)$  cm, and weight of  $34.90(\pm 11.65)$  kg respectively, from primary provincial school students in the South of Thailand was summarized into means, standard deviation and percentile at 1, 5, 50, 95, and 99. And the findings could be used as foot anthropometry data base compared to the research findings by the Office of Industrial Standard, Ministry of Industry in Phase 4 A.D. 2000-2001 [19]. These following details were concluded.

- 1) The comparison of the foot anthropometry between male and female students with the age of 7-12 from primary provincial school in the South of Thailand could be concluded that the male students had different (significant at  $P < 0.05$ ) foot size from the female students almost proportion items, except proportion item no. 7 foot length, proportion item no. 8 foot length, proportion item no. 9 foot length : heel to tip of little toe, proportion item no. 10 metatarsale fibulare (fibular instep length, proportion item no. 12 metatarsale tibiale (instep length, proportion item no. 14 heel breadth, proportion item no. 15 foot breadth, diagonal, proportion item no. 16 first toe length, proportion item no. 19 third toe length on side of second toe, proportion item no. 22 fourth toe length on side of fifth toe, proportion item no. 25 great toe height, proportion item no. 29 sphyrion height, proportion item no. 31, proportion item no. outside ball height.
- 2) The comparison of the subjects foot anthropometry with the age of 7-12 from primary provincial school students in the South of Thailand and the survey research of Thai foot structures in Phase 4 A.D. 2000-2001 by the Office of Industrial Standard, Ministry of Industry could be concluded that the male students had different (significant at  $P < 0.05$ ) foot size from the female students almost proportion items, except the foot length and foot breath.

- 3) The comparison of the female subjects foot anthropometry with the age of 7-12 from primary provincial school students in the South of Thailand and the survey research of Thai foot structures in Phase 4 A.D. 2000-2001 by the Office of Industrial Standard, Ministry of Industry could be concluded that the female students had different (significant at  $P < 0.05$ ) foot size from the female students almost proportion items, except the foot circumference, heel breadth, and sphyrion fibulare height.
- 4) The patterns of foot types could be classified into four main types. Pattern A is circular foot shape and it is called as short foot. Pattern B is narrowed and long foot shape and it is called as long foot. Pattern C is wide and narrow foot breath shape and it is called as small foot. Pattern D is wide breath foot shape and it is called as big foot.

#### ACKNOWLEDGMENT

The researcher would like to express his sincere gratitude to all the administrators and teachers of kindergarten schools in all 14 Southern provinces for their very kind cooperation. Many thanks also go to all primary school subjects for their lovely participation. This research was financially supported by the Rajamangala University of Technology Srivijaya.

#### REFERENCES

- [1] Pheasant, S.T., *Bodyspace: Anthropometry, Ergonomics and Design*, Taylor & Francis Ltd., London, U.K. 1986.
- [2] Intaranont, K., *Ergonomics*, Chulalongkorn University Printing, Bangkok, Thailand. 2005.
- [3] Kayis, B., Ozok, A.F., "Anthropometry survey among Turkish primary school children," *Applied Ergonomics*, 22, pp. 55-56, 1991.
- [4] Mououdi, M.A. and Choobineh. A.R., "Static anthropometric characteristics of student age range 6-11 in Mazandaran Province/Iran and school furniture design based on ergonomics principles," *Applied Ergonomics*, 28 (2), pp. 145-147, 1997.
- [5] Wang, M.J.J., Wang, E.M.Y., Lin, Y.C., "The anthropometric database for children and young adults in Taiwan," *Applied Ergonomics*, 33, pp. 583-585, 2002.
- [6] Prado-Leon, L.R., Avila-Chaurand, R., Gonzalez-Munoz, E.L., "Anthropometric study of Mexican primary school children," *Applied Ergonomics*, 32, pp. 339-345, 2001.
- [7] Leon, L.R., Chaurand, R.A. and Munoz, E.L., "Anthropometric study of Mexican primary school children," *Applied Ergonomics*, 32 (2), pp. 339-345, 2001.
- [8] Monica, P.B., M.A. Pedro, L.G. da Costa and A.S. Costa, "Anthropometric study of Portuguese workers." *Int. J. Ind. Ergonomics*, 35: pp. 401-410, 2005.
- [9] Bunch, R.P., "Foot measurement strategies for fitting athletes," *Journal of Testing and Evaluation*, 16 (4), pp. 407-411. 1988.
- [10] Chen, C.C., "An investigation into shoe last design in relation to the foot measurement and shoe fitting for orthopedic footwear," Ph.D. Thesis, University of London. 1993.
- [11] Cheng, F.T. and D.B. Perng, "A systematic approach for developing a foot size information system for shoe last design," *Int. J. Ind. Ergonomics*, 25: pp. 171-185, 1999.
- [12] Xiao, H., Ai, Q., "Foot shape study of children of Kazak nationality. Chinese," *Journal of Anatomy*, 23(3), 2000.
- [13] Luximon, A., Goonetilleke, R.S., "Foot shape modeling," *Human Factors* 46 (2), pp. 304-315. 2004.
- [14] Channa, P., S. Xiong, S. Ravindra and J. Zhao, "Foot measurements from three-dimensional scans a comparison and evaluation of different methods," *Int. J. Ind. Ergonomics*, 36: pp. 789-807, 2006.
- [15] Kanaani, J.M., S.B. Mortazavi, A. Khavanin, R. Mirzai, Y. Rasulzadeh and M. Mansurizadeh., "Foot anthropometry of 18-25 years old Iranian

- male students,” *Asian Journal of Scientific Research*, 3 (1): pp. 62-69, 2010.
- [16] Linghua Ran, Xin Zhang, Chuzhi Chao, and Taijie Liu, “Anthropometric measurement of the feet of Chinese children,” V.G. Duffy (Ed.): *Digital Human Modeling*, HCII 2011, LNCS 6777, pp. 30-36, 2011.
- [17] Goonetilleke, S. R., Ho, E. C. F., and So, H. Y. R., “Foot anthropometry in Hong Kong,” *Proceedings of the ASEAN 97 Conference*, Kuala Lumpur, Malaysia, 1997, pp. 81-88.
- [18] Maneerat Patchimasiri and Yuthachai Bunternngchit, “Study of foot anthropometry of Thai industrial workers,” *IE-network national conference*, Phuket, Thailand, 2007, pp. 1120-1126,
- [19] The Office of Industrial Standard, Ministry of Industry, Survey research of Thai foot structures in phase 4 A.D. 2000-2001. Bangkok, Thailand.
- [20] ISO 7250, Basic human body measurements for technological design. International Standard Organization, 2004.
- [21] Japanese Industrial Standard: JIS Z 8500: (E), Ergonomics-basic human body measurements for technological design, 2002.
- [22] Mayuree Sawan., T., *Science and Engineering Statistic*, King Mongkut's University of Technology North Bangkok, Printing., Bangkok, Thailand. 2001.
- [23] Montgomery, D.C., and Runger, G.C., *Applied Statistics and Probability for Engineers*, 4<sup>th</sup> ed. John Wiley & Son, Inc., 2007.