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Normative Study on Postural Stability in Standing for Different Ethnicity in Malaysia Measure by Functional Reach Test

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Abstract: The purposes of this study were to establish the norms of Functional Reach Test (FRT) values among different ethnicity (Malay, Chinese and Indian) from the age of 20 to 87 years and to compare mean of FRT between ethnicity. Effects of gender, age, height and weight and hand anthropometrics on FRT values were also studied. 135 healthy subjects from the age of 20 to 87 years participated in this study. The subjects; Malay (n = 55), Chinese (n = 35) and Indian (n = 45) were divided into 3 age groups which were 20 to 40 years, 41 to 69 years and 70 to 87 years. The measurement of FRT is the distance between arm's length and maximal forward reach with a fixed base of support. The only predictor of FR scores were age, height, wrist length and forefinger tip breath which accounted for 33% ($r^2 = 0.329$) of variation in FRT values. FRT values among ethnicity showed that only Backward Reach Test values have significant difference ($p < 0.05$) which are Indian subjects has the lowest scores compared to Malay and Chinese subjects. Examiners who are using FRT as a balance test should consider the normal values of FRT for Malaysian peoples especially for Backward Reach Test for Indian peoples. Future research should be done to investigate the subjects' level of fear of falling when performing FRT that may affect the scores.

Key words: Postural Stability · Functional Reach Test · Ethnicity · Anthropometrics

INTRODUCTION

Postural stability involves the control of the body's position in space in order to obtain stability and orientation [1]. For the purpose of stability, our body should have the ability to maintain center of mass within its base of support [2]. Limits of stability are not the same as balance but are one aspect of balance [3]. While orientation of the body involves the control of the relationship between the various body segments of the body. To obtain the goals of stability and orientation, an integration of sensory input from the visual, vestibular and somatosensory systems and motor output is needed [4]. Since balance control is a complex entity, it is difficult for a single test to measure all its aspects. However, it is important to specify what aspect of a balance test measures and to validate that the test does in fact reflect this aspect [5].

The Functional Reach Test (FRT) is one of a balance test that commonly used to assess fall risk in older adults. The growing segment of population which is older adults, falls is a leading cause of disability, injury, or death [6]. Falls are reported to be the main cause of death due to accidents or unintentional injury in persons aged 65 years and older [6]. So, it is important to assess peoples or clients for fall risk and there are vary measurement for motor skill performance. One commonly used tool, developed by Duncan *et al* and is the FRT [7]. FRT places the participants into 1 of 4 fall risk categories according to the distance they are able to reach. The 4 categories are low risk (more than 24.4 cm or 10 in), moderate risk (14.24-24.40 cm or 6-10 in), high risk (less than 14.24 cm or 6 in) and very high risk (unable to reach) [7].

Functional reach test was developed by Duncan *et al.* (1990) and they defined functional reach

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test as a measure for balance and is the differences in inches between arm's length and maximal forward reach using a fixed base of support. They also explained that this test can be used to detect balance impairment, change in balance performance over time and needed in modified environment for impaired older persons [7]. Functional reach test assess the limits of stability by measuring the maximum distance an individual can reach forward while standing in a fixed position of base of support [8]. While functional reach is defined by Stelmach and Worringham [9] as the maximum forward displacement that a subject can achieve, starting from and upright position with the dominant arm extended forward and with the fist closed so as to form a right angle with the torso, while simultaneously maintaining a fixed support and the fist always at the same level throughout the movement.

Height and ages demonstrate to gives the effect on functional reach test values. While gender was shown to has no effect on data of functional reach test [7, 10]. The study on children found that as the age increase, the height is also increase and then it will increase the FRT distance [11]. This is in contrast to the study by Duncan *et al* with adults subject (20 to 87 years) in which reach values decrease as age increased. But, subjects' height also influenced on FRT values [7].

The differences of hand anthropometric among different ethnic populations showed that the hand performance level also have differences [12]. Age and body anthropometrics such as height and hand length have significant correlation with the FRT distance [7]. In Malaysia, the major ethnic in this country are Malay, Chinese and Indian. Different populations have different in physical characteristics. A study had done by Volkman *et al*. (2005) to determined effects of subjects' characteristics on FRT in developing children. They stated that age of developing subjects give effect on reach score because of increase in height [1]). A few studies on anthropometric data of Malaysia populations showed that there are differences of body dimension between ethnic groups in Malaysia especially for height, weight and hand anthropometrics [13-15]). This study was developed to see whether the differences of height, weight and hand anthropometrics among different ethnics give effects on FRT distances. So, the purpose of this study is to (1) analyses the anthropometric data (height, weight and hand length) between ethnic groups in Malaysia and their effects on the FRT values (2) study whether there are any differences of FRT values between 3 ethnics.

MATERIALS AND METHODS

Participants: Subjects that participate in this study firstly completed the informed consent and profile sheet that contains demographic information. An interview was conducted to obtain the information of health conditions and current medical treatment in which used to screen the subjects according to screening criteria for both inclusion and exclusion factors. The screening criteria will enable us to identify the target population which is normal peoples and to exclude any criteria that could potentially affect the results of FRT. Subjects that have any of exclusion criteria then will exclude from participate in this study. We also measured the height, weight and hand anthropometric of the participants as independent variables and will recorded in the profile sheet. After conducted the measurement of FRT (Forward, Backward and Sideward Reach Test), the results are recorded in profile sheet.

The target population for this study involved normal peoples according to inclusion criteria. Samples that participate in this study are randomly selected in Malaysia populations for 3 ethnic groups which are Malay, Chinese and Indian as a representative group form Malaysian population. Selection of the samples are according to inclusion criteria from age 20 until 87 years old and healthy peoples. Sizes of samples in this study involved 135 subjects from the age of 20 to 87 years old. 135 subjects are dividing into 3 ethnics who are Malay (M = 35, F = 20), Chinese (M = 20, F = 15) and Indian (M = 20, F = 25) and each ethnic is divided into 3 age groups. The 3 age groups are 20-40 years old, 41-69 years old and 70-87 years old.

Interview was conducted to obtain the information of health conditions and current medical treatment in which used to screen the subjects. Subjects were excluded if they were less than the age of 20 years old and more than 87 years old, unable to follow instruction, have medical condition that affects ability to balance in standing or postural stability, suffer from neurological condition (e.g stroke, Parkinson, vestibular hypofunction, multiple sclerosis etc), have recent history of orthopedic injury or disease, or lack of active ankle range of motion in standing. 2 subjects were excluded from this study due to: complain of dizziness and unable to understand instructions.

Procedures: We also measure the height, weight and hand anthropometrics (hand length, arm length, forearm length, wrist length and forefinger tip breath) of the participants as independent variables.

The protocol established by Duncan *et al* was used for administering the FRT. Participants assumed a standing position close to a wall with feet comfortably apart while the examiner stood to one side. A meter stick was mounted on the wall at the height of the participant's acromion process. Subjects were informed that they would perform 1 practice trial and 3 recorded trials. Participants were asked to stand in normal, relaxed position with no shoes or socks were worn. To make sure the identical foot placement by subjects during the testing session, the foot position was placed at the front edge of a sheet of paper and stance width was obtained from the foot tracing. In addition, participants were asked to raise their dominant hand in a fisted position so that the arm was perpendicular to the floor and parallel to meter sticks. Subjects were asked to reach as far forward as possible without raising their heels, taking a step, or touching the wall. No attempt to control subject's method of reach. The subject held the reaching position for approximately 3 seconds while the reaching position was measured. The scores are recorded based on the end of the 3rd metacarpal by calculated the distance differences between the start and maximum reach position. The activity was demonstrated by examiner. In the original articles by Duncan *et al*, the participant performs 2 practice trials and 3 recorded trials (7, 16). To avoid fatigue, one practice trial was used in this study

RESULTS

One hundred thirty-seven subjects were screened by interview and 2 were excluded. Additional sample characteristics by Age Category and Ethnicity Groups are outlined in Table 1.

To compare mean of participants' height, weight and hand anthropometrics among ethnics of Malay, Chinese and Indian, One-way ANOVA test were used. The result showed that there is no mean differences of subjects' height ($p = 0.505$) and weight (0.567). Hand anthropometrics also showed the similar results. No mean differences of hand length ($p = 0.664$), arm length ($p = 0.608$), forearm length ($p = 0.080$), wrist length ($p = 0.672$) and forefinger tip breath ($p = 0.425$) between samples 3 ethnic groups.

The mean difference between Forward Reach and Backward Reach of Male and Female are statistically significant ($p = 0.001$, 95% CI = 2.054, 6.659), ($p = 0.015$, 95% CI = 5.77, 11.51). Male group reported to has higher mean for both Forward and Backward Reach which are 32.6 cm and 28.2 cm. While mean for female are 23.3 cm and 14.7 cm. Mean of Sideward Reach are not statistically significant difference between male and female (right, $p = 0.382$, 95% CI = 3.95, 9.24) (left, $p = 0.603$, 95% CI = 2.92, 7.41).

The mean of FRT values with a 95% CI, the mean decreased with age. With a 95% CI, if same samples size is use repeatedly from similar population, we are 95% confident that they include the population mean. By used Pearson Correlation, there is a significant different ($p<0.001$) with negative fair correlation ($r=-0.429$) between age of participants and the FRT values. Table 2 shows that all the FRT (forward, backward, right and left sideward reach) values are gradually decreased with increasing of ages. So, age influenced all four measures because as age increased, all the measured decreased. 18% ($r^2=0.184$) of variation in FRT values could be explained by age of participants by used linear regression. By comparing mean differences between age categories, result showed that there is significant difference of FRT values among 3 age category ($p < 0.001$). The mean are decreased with increasing of age category (Table 2).

Pearson correlation was used to identify the relationship between age, height, weight and hand anthropometrics with Forward Reach Test scores. For age, there is significant ($p<0.001$) with negative fair correlation ($r = -0.413$) with FRT. Besides that, height ($p<0.001$, $r = 0.493$), weight ($p < 0.001$, $r = 0.367$), hand length

Table 1: Descriptive Characteristics of Subjects by Age Category and Ethnicity Groups

				Hand Anthropometrics (cm) Mean (SD)				
		Height (cm) Mean (SD)	Weight (kg) Mean (SD)	Hand Length	Arm Length	Forearm Length	Wrist Length	Forefinger Tip Breath
Age Category	20 - 40 years	165.8 (8.13)	64.3 (13.64)	74.4 (4.34)	35.16 (1.78)	25.56 (3.79)	18.42 (1.47)	8.46 (1.36)
	41 - 69 years	161.5 (8.20)	69.0 (14.29)	72.5 (4.25)	34.38 (2.84)	24.83 (1.85)	18.15 (1.12)	8.65 (0.72)
	70 - 87 years	155 (8.42)	51.6 (11.06)	70.4 (3.55)	33.86 (2.45)	23.55 (1.21)	18.12 (2.46)	8.76 (3.68)
Ethnicity Groups	Malay	161.3 (7.97)	63.5 (15.95)	72.6 (3.50)	34.67 (2.27)	24.77 (1.47)	18.37 (1.30)	8.46 (1.38)
	Chinese	163.3 (7.24)	61.5 (13.05)	72.5 (3.28)	34.73 (2.31)	24.86 (1.96)	17.83 (2.05)	9.01 (3.29)
	Indian	161.2 (11.3)	65.0 (14.91)	73.3 (5.89)	34.84 (2.59)	26.01 (4.35)	18.42 (1.54)	8.44 (0.75)

Note: All measurement given in centimeter (cm)

Table 2: Functional Reach Test values by Age Category

		FRT Mean (SD)							
		Forward Reach		Backward Reach		Sideward Reach (right)		Sideward Reach (left)	
		M	F	M	F	M	F	M	F
Age Category	20 - 40 years	34.7 (4.88)	31.1 (5.58)	26.5 (8.03)	17.8 (7.20)	23.4 (9.84)	16.9 (3.62)	23.2 (7.28)	16.4 (3.45)
	41 - 69 years	33.1 (4.68)	30.6 (7.26)	25.3 (9.32)	15.5 (7.58)	21.2 (5.63)	16.6 (4.95)	20.2 (5.27)	17.6 (5.71)
	70 - 87 years	28.0 (1.62)	20.3 (3.78)	12.1 (1.40)	9.1 (3.27)	11.3 (1.37)	4.4 (2.31)	12.6 (2.46)	8.3 (4.56)

Note: All measurement given in centimeter (cm)

Table 3: Functional Reach Test for Ethnicity Groups

	Forward Reach Mean (SD)		Backward Reach Mean (SD)		Sideward Reach (right) Mean (SD)		Sideward Reach (left) Mean (SD)	
	M	F	M	F	M	F	M	F
Ethnicity Groups								
Malays	31.53 (4.55)	27.88 (6.33)	24.09 (10.63)	17.75 (7.17)	20.97 (9.19)	13.48 (7.09)	20.64 (7.64)	15.70 (5.41)
Chinese	32.15 (4.46)	29.33 (5.74)	23.35 (8.16)	17.53 (7.88)	20.23 (8.29)	13.10 (6.67)	18.90 (5.81)	14.77 (5.16)
Indian	35.70 (5.15)	27.82 (9.25)	22.2 (8.97)	10.56 (5.03)	19.03 (7.50)	14.14 (6.54)	20.05 (6.82)	14.24 (7.11)

Note: All measurement given in centimeter (cm)

($p<0.001$, $r = 0.436$), arm length ($p = 0.001$, $r = 0.289$), forearm length ($p = 0.001$, $r = 0.287$) and forefinger tip breath ($p < 0.001$, $r = 0.434$) are significant, positive fair correlation with FRT. While there is significant ($p = 0.006$, $r = 0.237$), poor, positive correlation between wrist length and FRT.

Multiple Linear regression analysis was performed to examine the influence of age, height, weight and hand anthropometrics on the FRT values. We found that, there is significant linear relationship between subject's age ($p=0.022$, 95% CI=-0.161,-0.013), height ($p=0.222$, 95% CI=-0.091, 0.387), wrist length ($p = 0.225$, 95% CI = -1.867, 0.444) and forefinger tip breath ($p = 0.283$, 95% CI = -1.176, 3.989) with Forward Reach Test values. Subject's weight ($p=0.445$, 95% CI=-0.054, 0.122) showed that no relationship with FRT values. All hand anthropometrics also have no relationship with FRT values. So, the only predictor of FRT scores was age, height, wrist length and forefinger tip breath which accounted for 33% ($r^2 = 0.329$) of variation in FRT values.

One-way ANOVA test was used to assess whether the mean of FRT values (forward, backward and sideward) are statistically significantly different among the 3 ethnics (Malay, Chinese and Indian). From the analysis, we found that no mean differences ($p = 0.705$) for Forward Reach values among all 3 ethnics. Result also found that no mean differences of Right Sideward Reach ($p = 0.515$) and Left Sideward Reach ($p = 0.304$) score among ethnicity groups

Result is different for Backward Reach. There is at least one pair of mean differences ($p = 0.003$) for Backward Reach values among ethnicity category. So, Post-hoc analysis is used to determine which pair is significantly a difference. Subsequently post-hoc analysis (scheffe procedure) suggests that the mean of Backward Reach values are significantly different between 'Malay and Indian' and 'Chinese and Indian'. We observed that Indian has the lowest Backward Reach values as compare to Malay and Chinese (Table 3).

DISCUSSION

The anthropometrics measurements of the subjects are taken before the FRT are performed for all 3 ethnics included the subjects' height, weight and hand anthropometrics (hand length, arm length, forearm length, wrist length and forefinger breath). The recorded data found that the mean values for all the anthropometrics are no differences between Malay, Chinese and Indian. The anthropometric study proposed by Karmegam *et al*, Deros *et al.* and Rosnah *et al.* [13-15] showed the different results. They found that Malaysian peoples have different anthropometric between ethnics including height, weight and hand length.These differences may be due to different of samples size of subjects' participation. Their anthropometrics study involved large sample size that gives more accuracy on the data because it is projecting the entire population of body dimension.

Mean of Forward Reach Test according to age category from this study found that, age group of 20 to 40 years are 34.7 cm (M) and 31.1 cm (F). While age group of 41 to 69 years found that the mean of FRT are 33.1 cm (M) and 30.6 cm (F) and for 70 to 87 years are 28.0 cm (M)

and 20.3 cm (F). For adult normal values study by Duncan *et al* (1990 and 1992) for mean of functional reach from age 20-87 years found that age group of 20- 40 years reached 42.4 cm (M) and 37.1 cm (F). Age groups of 41 - 69 years are 37.8 cm (M) and 35.1 cm (F). While for 70 - 87 years, the subjects reached 33.5 cm (M) and 26.7 cm (F) [7, 16]. This FRT distance differences between this study and the study by Duncan *et al* may because of anthropometrics differences between these 2 samples of populations. The International Day for Evaluation of Abdominal Obesity (IDEA) study confirms that BMI is lower in Asian compared to European population. Subjects' height found to effect the FRT distance [7]. So, these differences of height showed the differences of FRT values for these differences populations.

The result of the FRT values between gender showed that there are mean differences between Male and Female for Forward Reach Test ($p = 0.001$) and Backward Reach Test ($p = 0.015$). The Forward and Backward Reach scores showed higher mean values compared to female. Study by Duncan *et al.* [7] showed the similar results which is analysis of reach capabilities by gender reveals that Male has a longer reach than Female. However, he noted that the differences in height are more contribute to FR scores compared to gender. These gender differences of scores may be affected by the anthropometric differences between Male and Female subjects [15]. While analysis for Sideward Reach test in this study found that no mean differences found between Male and Female which are Right Sideward Reach Test p values is 0.382 and Left Sideward Reach Test is 0.603.

Age influenced the all four measures (forward, backward, right and left sideward reach). This study found that age has negative correlation with FRT values ($r = -0.429$). The FRT values seemed too decreased as age increased. The comparison of FRT mean between age categories also showed that there are significant differences of FRT values with age category. Besides that, linear regression analysis found 18% of the variance in FRT values was affected by age alone. This finding is similar with other published data [7].

The relationship between FRT and age, height, weight and hand anthropometric were fairly associated ($r = 0.25 - 0.50$) except for wrist length ($r = <0.25$) which is poor correlation. The effects of age, height, weight and hand anthropometrics on FRT were determined using multiple linear regression analysis. We found that, the subjects' age and height did significantly explain the variance in FRT with the total of 33% of variance. While the subject's weight and hand anthropometrics did not meet the necessary criteria to significantly impact with FRT scores. From the original study by Duncan *et al.* [7] also presented that age and height was highly associated with FRT [7]. But, the results are different from the study done by Jonsson, *et al.* [5] showed that no correlation between age, height and FR scores (5). Same as the study on elder peoples by Wernick-Robinson *et al.* [17] found that no significant correlation between age and height with FR distance [17]. The explanation may be these studies only involved a smaller age span (older adults).

By comparing the mean of FRT with ethnicity groups using one-way ANOVA test, we found that Forward Reach scores have no mean differences among all 3 ethnics. The result is similar for right and left Sideward Reach scores which is no differences among Malay, Chinese and Indian subjects. This may be due to no mean differences of subjects' height and hand anthropometric among all subjects within ethnics from this study that give no effects on FRT values. Backward Reach Test mean values seemed to have differences for different ethnicity. Further Post-hoc analysis showed that significant differences between 'Malay and Indian' and 'Chinese and Indian. Indian subjects found to be the lowest Backward Reach distance compared to Malay and Chinese. Newton [18] found in his study that Backward reach score are significantly affect by fear of falling, as measured by the Fear of Falling Index. Fear may be contributing to decrease the amount of Backward Reach Test values among Indian subjects.

As a conclusion, among 3 ethnic groups, this study found that no differences of anthropometrics dimension which are height, weight, hand length, arm length, forearm length, wrist length and forefinger tip breath between ethnicity. The subjects' ages and height seemed to influence the FRT scores. From this study also showed that Male has higher FRT scores compared to Female. Age influenced all 4 measures of FRT with negative correlation. The FRT values seemed to decrease as age increased. FRT values among ethnicity showed that only Backward Reach Test values have significant difference between 'Malay and Indian' and 'Chinese and Indian' which are Indian has the lowest scores. FRT indicate as a feasible clinical test that examines the dynamic postural control or balance in standing of adults to older adults (20 - 87 years). Use of the FRT may allow the examiner to identify peoples with potential balance deficits. The FRT may be used with other clinical test to assess balance ability or any balance impairment.

CONCLUSIONS

Examiners who are using FRT as a balance test should consider the normal values of FRT for Malaysian people especially for Backward Reach Test among Indian population. Future research should be done to understand and investigate the subjects' level of fear of falling when performing FRT that may affect the scores. For further study on normative data, it should involve larger sample size and the variety of location should be cover in order to represent each ethnicity for Malaysian populations.

REFERENCES

1. Massion, J., 1898. Postural control systems in developmental perspective. Neuroscience and Biobehavioral Review, 22: 465-472.
2. Horak, F.B., 1987. Clinical measurement of postural control in adults. Physical Therapy, 67: 1881-1885.
3. Shumway, C., 2000. Motor control: theory and practical applications. Recherche, 67: 02.
4. Brogren, E., M. Hadders-Algra and H. Forssberg, 1998. Postural control in sitting children with cerebral palsy. Neuroscience and Biobehavioral Reviews, 22: 591-596.
5. Jonsson, E., M. Henriksson and H. Hirschfeld, 2003. Does the functional reach test reflect stability limits in elderly people? Journal of rehabilitation medicine, 35: 26-30.
6. Ingemarsson, A.H., K. Frandin, K. Hellstrom and A. Rundgren, 2000. Balance function and fall-related efficacy in patients with newly operated hip fracture. Clinical Rehabilitation, 14: 497-505.
7. Duncan, P.W., D.K. Weiner, J. Chandler and S. Studenski, 1990. Functional reach: a new clinical measure of balance. Journal of Gerontology, 45: M192-M197.
8. DeWaard, B.P., B. Bentrup, J. Hollman and J. Brasseur, 2002. Relationship of the functional reach and lateral reach tests in elderly females. Journal of Geriatric Physical Therapy, 25: 4.
9. Stelmach, G. and C. Worringham, 1985. Sensorimotor deficits related to postural stability. Implications for falling in the elderly. Clinics in Geriatric Medicine, 1: 679.
10. Rediske, S., S. Schwartz and S. Chattopadhyay, 1998. The Effects of Height on Funtional Reach Test Outcomes. Journal of Neurologic Physical Therapy, 22: 170.
11. Donahoe, B., D. Turner and T. Worrell, 1994. The use of functional reach as a measurement of balance in boys and girls without disabilities ages 5 to 15 years. Pediatric Physical Therapy. 6: 189.
12. Gnaneswaran, V. and R. Bishu, 2011. Anthropometry and hand performance evaluation of minority population. International Journal of Industrial Ergonomics.
13. Deros, B., D. Darui and M. Nor, 2008. Fundamental sitting anthropometric and differences among Malaysian Malays, Chinese and Indians. Advanced manufacturing research group'08 Seminar Vol. 1
14. Karmegam, K., S. Sapuan, M. Ismail, N. Ismail, M.T.S. Bahri S. Shuib, Mohana, K.P. Seetha, P. Tamilmoli and M. Hanapi, 2011. Anthropometric study among adults of different ethnicity in Malaysia. International Journal of Physical Science. 6(4): 777-788.
15. MY R, H.M. Rizal and S.N. SAR, 2009. Anthropometry dimensions of older Malaysians: Comparison of age, gender and ethnicity. Asian Social Science, 5: 133.
16. Duncan, P.W., S. Studenski, J. Chandler and B. Prescott, 1992. Functional reach: predictive validity in a sample of elderly male veterans. Journal of Gerontology, 47: M93-M98.
17. Wernick-Robinson, M., D.E. Krebs and M.N. Giorgetti, 1999. Functional reach: Does it really measure dynamic balance? Archives of physical medicine and Rehabilitation, 80: 262-269.
18. Newton, R.A., 2001. Validity of the Multi-Directional Reach Test. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 56: 248-252.