Postural stability and dynamic balance in Thai community dwelling adults

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Introduction   :   The distance limit that people can lean or maintain their stability is very important for their daily activities. As people grow older, in particular after the age of 65 years, the somatosensory and vestibular function decline rapidly to the extent that it may disrupt the balance of the body and cause them to fall down.

Objectives   :   To measure postural stability and dynamic balance in normal adults and the elderly.

Research design   :   Cross sectional descriptive study.

Methods   :   The End Point Excursion (the distance of the first movement toward the designated target) and the Maximum Excursion (the maximum distance) were measured in 120 healthy male and female age 30 -40 and 60 - 70 years using Balance Master 8.0, Neurocom, OR.

Results   :   Age has the effect on postural stability and dynamic balance more than gender. In the same age group, the End point Excursion and the Maximum Excursion of the female and male age 60 – 70 years reduced 34.25 % and 21.21 % respectively especially in the Forward direction compared with the female and male age 30 - 40 years.

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Conclusions	:	*Age is a significant variable that influence postural stability and dynamic balance as elderly people have the ability to reach especially in the forward direction less than the younger group.*
Keywords	:	*Postural stability, Dynamic balance.*

ปัญหา/เหตุผลในการทำวิจัย : เป็นสิ่งที่จำเป็นมากในการศึกษาปัจจัยที่เกี่ยวกับการทรงท่าและการทรงตัวเมื่อมีการเคลื่อนที่ในผู้สูงอายุที่มีการเสื่อมลงของระบบการรับความรู้สึกและระบบการทรงตัว เพื่อเป็นข้อมูลเบื้องต้นในการศึกษาวิจัยต่อไป

รูปแบบการวิจัย : การศึกษาแบบพรรณนา (descriptive study)

วัตถุประสงค์ : เพื่อศึกษาการทรงท่าและการทรงตัวเมื่อมีการเคลื่อนที่ของประชากรไทยในชุมชนแห่งหนึ่ง

วิธีการ : คัดเลือกกลุ่มประชากรโดยวิธีการสุ่มตัวอย่างจากผู้ที่มีคุณสมบัติตามเกณฑ์ที่กำหนดจำนวน 120 คน หญิงและชายอายุ 30 40 ปี และ 60 – 70 ปี ทุกคนได้รับการทดสอบการทรงท่าและการทรงตัวเมื่อมีการเคลื่อนที่ โดยใช้เครื่อง Balance Master, Neurocom 8.0, OR ทำการทดสอบ End Point Excursion (ระยะในการเคลื่อนที่ครั้งแรก) และ Maximum Excursion (ระยะที่เคลื่อนที่ได้มากที่สุด) และนำผลที่ได้มาวิเคราะห์ โดยใช้ unpaired t- test จากโปรแกรม SPSS version 10.0

ผลการวิจัย : อายุ มีผลต่อการทรงท่าและการทรงตัวแบบมีการเคลื่อนที่ ชายและหญิง อายุ 60 - 70 ปี มีการลดลงของ End Point Excursion และ Maximum Excursion 34.25 % และ 21.21 % ตามลำดับในทิศทางด้านหน้า (Forward) มากที่สุด เมื่อเปรียบเทียบกับ ชายและหญิง อายุ 30 - 40 ปี

สรุปผลการวิจัย : อายุ มีผลต่อความมั่นคงในการทรงท่า (postural stability) และการทรงตัวแบบมีการเคลื่อนที่ (dynamic balance) ดังนั้นในผู้สูงอายุ (60 - 70 ปี) จะเอื้อมไปหยิบของทางด้านหน้า ยากกว่า ชายและหญิง อายุ 30 - 40 ปี

คำสำคัญ : ความมั่นคงในการทรงท่า, การทรงตัวแบบมีการเคลื่อนที่

There are three types of measures used to evaluate the balance function by force platform systems namely: sway measures, symmetry measures, and limits of stability measures.[1]

The limits of stability is the maximal distance an individual can lean in any direction without losing balance; these limits describe a cone projecting about the feet with maximal displacement equal to 8 degrees anteriorly, 4 degrees posteriorly, and 8 degrees laterally to each side of the body.[2]

In a normal individual, during in-place standing, the center of gravity (COG) sways randomly within the limits of stability. When the COG is offset in a certain direction, as in bending forward or backward, small sway angles in the direction of that offset moves the COG beyond the perimeter of the limits of stability.[3]

When the COG moves beyond the limit of stability, a fall occurs unless a stumble or a rapid step repositions the base of support beneath the COG, securing additional support and enlarging the base of support.[4]

To move the body in phase with the head, there is an "ankle strategy"—that is, an acute recruitment of muscles from distal to proximal, with the ankle as a fulcrum.[5] When the COG approaches the outer limit of the base of support, a "hip strategy" is employed to maintain uprightness. Recruiting muscles from proximal to distal, the COG is moved in the opposite direction of the trunk movement.[6]

The Limits of Stability (LOS) Test used in this study only quantifies the end point excursion and maximum excursion a person can intentionally displace their center of gravity (COG) without losing balance, stepping, or reaching for assistance in eight

directions. To achieve these movements, one has to use the dynamic balance reaction to maintain the postural stability.[7] The control of posture is known to be critical for both the acquisition and control of motor abilities and is an essential requirement for physical activities in daily life.[8] Balance depends on the feedback of sensory information from visual, vestibular and somatosensory sources. The central nervous system processes the information by comparing them to a 'postural' body scheme built by the subject's anterior experience, and on reflex motor activities.[9] Somatosensory and vestibular functions link to postural stability decline rapidly after the age of 65 years to the extent that it can impact balance and contribute to falls.[10-17]

Expanding the limits of stability should decrease the likelihood of falling because the larger the limit of stability; the further a person can lean without the need to raise his/her toes or take a step, the less likely that the person is to fall. This relationship has been evaluated in few studies. So it is worthwhile to study in Thai population to examine their limits of stability using standard equipment (Balance Master 8.0,Neurocom, OR) to get the basic information comparing adults from older adults in both male and female. This study focuses only on one urban community close to Chulalongkorn University for evaluation.

Materials and Methods

The researchers used a cross sectional descriptive study to assess the Maximum Excursion (the maximum distance achieved during the trial and is shown in percentage) and the End Point Excursion (the distance of the first movement toward the

designated target and expressed as a percentage of maximum LOS distance) of two groups of community dwelling adults, both male and female, age 30 – 40 years and 60 -70 years old.

All subjects attended one test session which began with short interview to confirm for the inclusion and exclusion criterias and then signed the inform consent. We measured height, weight and blood pressure. Then the height and age data were entered to the Neurocom Data Base System in preparation for testing balance.

All subjects were asked to lean their bodies in eight given directions within eight seconds (Forward, Right Forward, Right, Right Backward, Backward, Left Backward, Left and Left Forward) and displace their center of gravity (COG) without losing their balance, stepping, or reaching for assistance and held that position in a given box demonstrated on the computer moniter.

Subjects

One hundred and twenty subjects living in the community for at least six months were randomized under the following inclusion criteria as following: male and female adult, age 30 – 40 years and, 60 -70 years old, report no difficulties or need for help in performing self-care or instrumental activities of daily living, are able to walk for at least 400 meter and exclusion criteria as followings; having history of one or more unexplained falls related to loss of balance within the past 12 months, having current or past medical diagnosis of injury affecting balance within the last 3 years; taking medication affecting the central nervous system or known to affect balance or coordination; having current symptoms of dizziness

or lightheadedness; having orthopedic or neurologic diagnosis or symptoms suggestive of vestibular or neurologic disorders; being not_able to stand for 10 minutes without the use of assistive device; being not able to raise and keep one arm parallel to the ground while leaning forward; having pain that would limit their ability to stand or reach; and having abnormal vision or uncorrected vision). [18]

Measurements

All subjects performed the end point excursion and maximum excursion tests which are two of the five tests of the Limit of Stability (LOS) Test in eight directions : Front (F), Right Front (RF), Right (R), Right Back (RB), Back (B), Left Back (LB), Left (L), and Left Front (LF).

Data Analyses

All data were analyzed using the SPSS 10.0 statistical package for Windows, Means and standard deviations were calculated for the outcome variables.

Unpaired t - test was used to compare all parameters between the two age groups in the same gender and the different gender within the same age group. After that all subjects at the same age groups (female & male age 30-40 years and female & male age 60-70 years) were compared using the unpaired t – test and the 95 % CI.

Results

The descriptive statistics of demographic data for the subjects enrolled in this study are presented in Table 1. One hundred and twenty subjects were divided into four groups according to their age and gender, i.e. female aged 30 - 40 years, female aged 60 – 70

Table 1. Demographic data of subjects in each group of this study.

	F 30 - 40 year n = 30	F 60 - 70 year n = 30	M 30 – 40 year n= 30	M 60 – 70 year n = 30
Age (yr)	35.67 (3.03)	64.37 (3.53)	35.37 (3.25)	63.93 (2.89)
Weight (kg.)	55.29 (9.83)	57.19 (13.08)	68.54 (8.63)	62.83 (10.27)
Height (cm.)	150.93 (8.29)	151.78 (5.93)	165.63 (6.45)	161.16 (6.29)
BMI(kg/m^2)	23.96 (3.86)	25.57 (3.74)	24.97 (2.73)	24.08 (3.21)

Data are shown as mean (standard deviation)

years, male aged 30 – 40 years and male aged 60 – 70 years old.

Results of The End Point Excursion between two age and gender groups are shown in Table 2 and 3.

There is a significant different between female age 60 -70 years and 30 – 40 years in six directions (Front, Right Front, Right, Right Back, Back, Left Back) at the p level of 0.006, <0.001, 0.001, 0.002 , 0.026, 0.025 respectively while there is a significant different between male age 60 -70 years and 30 – 40 years in two directions (Front and Right Front) at the p level <0.001

Table 2. The End Point Excursion (the distance of the first movement toward the designated target and expressed as a percentage of maximum LOS distance) of the same gender group in eight directions: Front (F), Right Front (RF), Right (R), Right Back (RB), Back (B), Left Back (LB), Left (L), and Left Front (LF).

	F 30 - 40 year n = 30	F 60 - 70 year n = 30	P Value	M 30 - 40 year n = 30	M 60 - 70 year n = 30	P Value
F (%)	70.80 (23.44)	53.93 (22.79)	0.006*	77.00 (22.37)	43.15 (22.40)	<0.001*
RF (%)	88.83 (23.76)	62.77 (29.84)	< 0.001*	93.17 (20.01)	67.73 (23.15)	< 0.001*
R (%)	87.87 (26.85)	61.83 (32.43)	0.001*	86.53 (17.23)	81.60 (21.97)	0.337
RB (%)	78.90 (25.95)	54.70 (30.60)	0.002*	75.13 (26.95)	63.73 (23.67)	0.087
B (%)	59.27 (16.71)	49.67 (15.91)	0.026*	55.10 (17.33)	48.73 (18.10)	0.180
LB (%)	79.33 (23.11)	65.13 (24.68)	0.025*	82.03 (22.54)	64.43 (24.68)	0.005
L (%)	94.37 (17.93)	83.27 (25.55)	0.056	92.23 (16.44)	85.20 (25.24)	0.206
LF (%)	93.83 (27.39)	82.90 (27.10)	0.126	92.40 (23.44)	83.33 (22.93)	0.135

Data are shown as mean (standard deviation)

* P (significant difference) at 0.05 level unpaired t - test

Table 3. The End Point Excursion (the distance of the first movement toward the designated target and expressed as a percentage of maximum LOS distance) of the same age group in eight directions: Front (F), Right Front (RF), Right (R), Right Back (RB), Back (B), Left Back (LB), Left (L), and Left Front (LF).

	F 30 - 40 year n = 30	M 30 - 40 year n = 30	P Value	F 60 - 70 year n = 30	M 60 - 70 year n = 30	P Value
F (%)	70.80 (23.44)	77.00 (22.37)	0.299	53.93 (22.79)	43.15 (22.40)	0.070
RF (%)	88.83 (23.76)	93.17 (20.01)	0.448	62.77 (29.84)	67.73 (23.15)	0.474
R (%)	87.87 (26.85)	86.53 (17.23)	0.820	61.83 (32.43)	81.60 (21.97)	0.008*
RB (%)	78.90 (25.95)	75.13 (26.95)	0.583	54.70 (30.60)	63.73 (23.67)	0.206
B (%)	59.27 (16.71)	55.10 (17.33)	0.347	49.67 (15.91)	48.73 (18.10)	0.837
LB (%)	79.33 (23.11)	82.03 (22.54)	0.649	65.13 (24.68)	64.43 (24.68)	0.913
L (%)	94.37 (17.93)	92.23 (16.44)	0.633	83.27 (25.55)	85.20 (25.24)	0.769
LF (%)	93.83 (27.39)	92.40 (23.44)	0.828	82.90 (27.10)	83.33 (22.93)	0.947

Data are shown as mean (standard deviation)

* P (significant difference) at 0.05 level unpaired t - test

There is a significant difference between female and male age 60-70 years in one direction (Right) at the p level 0.008

Results of the Maximum Excursion between two age and gender groups are shown in Table 4 and 5.

Table 4. The Maximum Excursion (maximum distance shown in percent) of the of the same gender group in eight directions : Front (F), Right Front (RF), Right (R), Right Back (RB), Back (B), Left Back (LB) Left (L), and Left Front (LF).

	F 30 - 40 year n = 30	F 60 - 70 year n = 30	P Value	M 30 - 40 year n = 30	M 60 - 70 year n = 30	P Value
F (%)	94.67 (12.61)	72.67 (22.28)	0.006*	99.03 (12.08)	79.97 (17.93)	< 0.001*
RF (%)	105.87 (9.86)	90.93 (24.77)	< 0.001*	105.70 (6.24)	93.90 (11.76)	< 0.001*
R (%)	106.87 (7.68)	94.23 (16.65)	0.003*	102.40 (6.66)	97.00 (11.78)	0.034*
RB (%)	105.57 (13.03)	86.97 (29.88)	0.001*	97.60 (16.71)	86.17 (23.20)	0.033*
B (%)	84.27 (17.80)	69.17 (22.59)	0.003*	78.20 (16.16)	66.97 (28.23)	0.065
LB (%)	100.10 (14.35)	82.17 (22.15)	< 0.001*	97.57 (11.71)	88.73 (27.60)	0.115
L (%)	105.97 (6.44)	100.03 (12.20)	0.022*	102.87 (7.20)	102.10 (10.14)	0.737
LF (%)	110.73 (10.21)	103.37 (16.41)	0.041*	110.43 (8.61)	106.87 (8.37)	0.109

Data are shown as mean (standard deviation)

* P (significant difference) at 0.05 level unpaired t - test

Table 5. The Maximum Excursion (maximum distance shown in percent) of the same age group in eight directions : Front (F), Right Front (RF), Right (R), Right Back (RB), Back (B), Left Back (LB), Left (L), and Left Front (LF).

	F 30 - 40 year n = 30	M 30 - 40 year n = 30	P Value	F 60 - 70 year n = 30	M 60 - 70 year n = 30	P Value
F (%)	94.67 (12.61)	99.03 (12.08)	0.176	72.67 (22.28)	79.97 (17.93)	0.167
RF (%)	105.87 (9.86)	105.70 (6.24)	0.938	90.93 (24.77)	93.90 (11.76)	0.556
R (%)	106.87 (7.68)	102.40 (6.66)	0.019*	94.23 (16.65)	97.00 (11.78)	0.460
RB (%)	105.57 (13.03)	97.60 (16.71)	0.044*	86.97 (29.88)	86.17 (23.20)	0.908
B (%))	84.27 (17.80)	78.20 (16.16)	0.172	69.17 (22.59)	66.97 (28.23)	0.740
LB (%)	100.10 (14.35)	97.57 (11.71)	0.457	82.17 (22.15)	88.73 (27.60)	0.314
L (%)	105.97 (6.44)	102.87 (7.20)	0.084	100.03 (12.20)	102.10 (10.14)	0.478
LF %)	110.73 (10.21)	110.43 (8.61)	0.902	103.37 (16.41)	106.87 (8.37)	0.304

Data are shown as mean (standard deviation)

* P (significant difference) at 0.05 level unpaired t - test

There is a significant difference between female age 60 -70 years and 30 – 40 years in eight directions (Front, Right Front, Right, Right Back, Back, Left Back, Left and Left Front) at the p level of 0.006, < 0.001, 0.001, 0.003 , 0.001, 0.003, < 0.001, 0.022 and 0.041 respectively; whereas there is a significant difference between male age 60 -70 yeas and 30 – 40 years in four directions (Front, Right Front, Right and Right Back) at the p level < 0.001, < 0.001, 0.034 and 0.033, respectively.

There is a significant difference between female and male age 30-40 years in two directions (Right and Right Back) at the p level 0.019 and 0.044, respectively.Results of the End point Excursion between the two age groups are shown in table 6 and fig 1.

There is a significant difference between female & male age 60 -70 years and female & male age 30 – 40 years in eight directions (Front, Right Front, Right, Right Back, Back, Left Back, Left and

Left Front) at the p level of < 0.001, < 0.001, 0.001, < 0.001, < 0.001, < 0.001, < 0.001, < 0.05 and < 0.05, respectively.

Fig 1. The End point Excursion was shown in all directions while.

1 : represent the distance of the first movement toward the designated target and expressed as a percentage of maximum LOS distance in female & male age 30 – 40 years.

2 : represent the distance of the first movement toward the designated target and expressed as a percentage of maximum LOS distance in female & male age 60 -70 years.

From fig 1. The female & male group age 60 -70 years have 34.25 %, 28.30 %, 17.75 %, 23.11 %, 13.96 %, 19.71 %, 9.72 % and 10.64 % of the female & male group age 30 – 40 years in Front, Right Front, Right, Right Back, Back, Left Back, Left and Left Front direction respectively.

Table 6. The End Point Excursion (the distance of the first movement toward the designated target and expressed as a percentage of maximum LOS distance) of the same age group (female and male) in eight directions : Front (F), Right Front (RF), Right (R), Right Back (RB), Back (B), Left Back (LB), Left (L), and Left Front (LF).

Direction	F & M 30-40 years N=60	F & M 60-70 years N=60	P value
F	72.9 (22.93)	48.59 (23.05)	< 0.001
95 % CI	(67.98, 79.82)	(42.59, 54.50)	
RF	91.00 (21.89)	65.25 (26.60)	< 0.001
95 % CI	(85.35, 96.65)	(58.38, 72.12)	
R	87.20 (22.37)	71.72 (29.22)	0.001
95 % CI	(81.42, 92.98)	(64.17, 79.26)	
RB	77.02 (26.30)	59.22 (27.50)	< 0.001
95 % CI	(70.22, 83.81)	(52011, 66.32)	
B	57.18 (17.01)	49.20 (17.38)	< 0.001
95 % CI	(52.79, 61.58)	(52.11, 66.32)	
LB	80.68 (22.67)	64.78 (24.47)	< 0.001
95 % CI	(74.83, 86.54)	(58.46, 71.11)	
L	93.30 (17.09)	84.23 (25.20)	< 0.05
95 % CI	(88.89, 97.71)	(77.72, 90.74)	
LF	93.12 (25.29)	86.12 (24.89)	< 0.05
	(86.58, 99.65)	(76.69, 89.55)	

Data are shown as mean (standard deviation)

* P (significant difference) at 0.05 level unpaired t - test

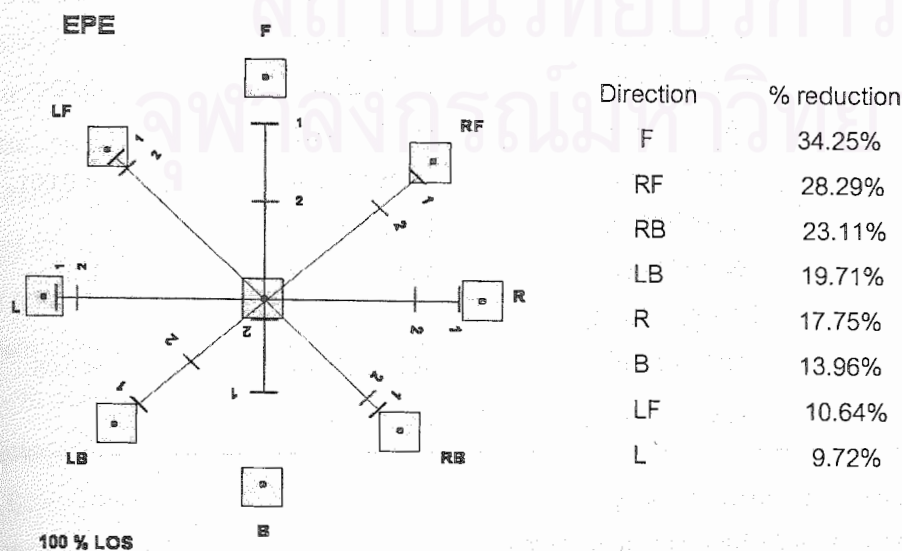| Direction	% reduction
F	34.25%
RF	28.29%
RB	23.11%
LB	19.71%
R	17.75%
B	13.96%
LF	10.64%
L	9.72%

Fig 1

Results of the Maximum Excursion between the two age groups are shown in table 7 and fig 2.

There is a significant difference between female & male age 60 -70 years and female & male age 30 – 40 years in eight directions (Front, Right Front, Right, Right Back, Back, Left Back, Left and Left Front) at the p level of <0.001, < 0.001, < 0.001, < 0.001, 0.001, < 0.001, 0.05 and < 0.05 respectively.

Fig.2 Maximum Excursion.

1 : represent the maximum distance shown in percent toward the designated target in female & male age 30 – 40 years.

2 : represent represent the maximum distance shown in percent toward the designated target in female & male age 60 -70 years.

From fig 2.The female & male group age 60 -70 years can move maximally in 21.20 %, 12.63 %, 8.61 %, 14.78 %, 16.20 %, 13.54 %, 3.21 % and 14.974 % of the female & male group age 30 – 40 years in Front, Right Front, Right, Right Back, Back, Left Back, Left and Left Front direction respectively.

Table 7. Maximum Excursion.

Direction	F & M 30 - 40 years N = 60	F & M 60 - 70 years N = 60	P value
F	96.85 (12.44)	76.32 (20.38)	< 0.001
95 % CI	(93.64, 100.06)	(71.05, 81.58)	
RF	105.78 (8.19)	92.42 (19.29)	< 0.001
95 % CI	(103.67, 107.90)	(87.43, 97.40)	
R	104.63 (7.47)	95.62 (14.37)	< 0.001
95 % CI	(102.70, 106.56)	(91.91, 99.33)	
RB	104.58 (15.39)	86.57 (26.52)	< 0.001
95 % CI	(97.61, 105.56)	(79.71, 93.42)	
B	81.23 (17.13)	68.07 (25.37)	0.001
95 % CI	(76.81, 85.66)	(61.51, 74.62)	
LB	98.83 (13.05)	85.45 (25.03)	< 0.001
95 % CI	(95.46, 102.00)	(78.99, 91.92)	
L	104.42 (6.95)	101.07 (11.17)	0.05
95 % CI	(102.62, 106.21)	(98.18, 103.95)	
LF	110.58 (9.36)	105.12 (13.04)	< 0.05
	(108.17, 113.00)	(101.75, 108.48)	

Data are shown as mean (standard deviation)

* P (significant difference) at 0.05 level unpaired t - test
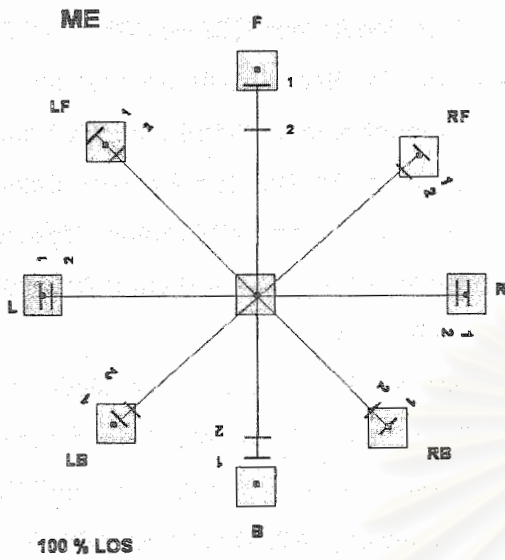
DIRECTION	%REDUCTION
F	21.20%
B	16.20%
RB	14.78%
LB	13.54%
RF	12.63%
R	8.61%
LF	4.94%
L	3.21%

Fig 2

Discussion

To compare the difference between the End Point Excursion and the Maximum Excursion of the four age groups we found that for the End Point Excursion, in the same gender there is a significant difference between female age 60 – 70 years and female age 30 – 40 years in six directions (Front, Right Front, Right, Right Back, Back, Left Back) at the p level of 0.006, < 0.001, 0.001, 0.002, 0.026, 0.025 respectively; whereas there is a significant difference between male age 60 -70 years and 30 – 40 years in two directions (Front and Right Front) at the p level < 0.001 only. From this study we found that male age 60-70 years have the distance of the first movement towards the designated target in more directions than women of the same age comparing with the same younger age groups (30-40 years). In the same age group there is a significant difference between female age 60 – 70 years and male age 60 -70 years in only one directions (Right) at the p level of 0.008.

Comparing the difference between the Maximum Excursion of the four age groups we found

that in the same gender group there is a significant difference between female age 60 – 70 years and female age 30 –40 years in eight directions (Front, Right Front, Right, Right Back, Back, Left Back, Left and Left Front) at the p level of 0.006, < 0.001, 0.003, 0.001, 0.003, < 0.001, 0.022 and 0.041, respectively; whereas there is a significant difference between male age 60 -70 years and 30 – 40 years in four directions (Front , Right Front, Right and Right Back) at the p level < 0.001, < 0.001, 0.034 and 0.033 respectively. From this study we found that male age 60 - 70 years have the maximum distance in more directions comparing with the younger (30-40 years). In the same age group there is a significant difference between female age 30 - 40 years and male age 30-40 years in two directions (Right and Right Back) at the p level of 0.019 and 0.044. It maybe because at this age the male are physically are stronger than the female.

From these two studies age has the effect on postural stability and dynamic balance more than the gender effect, so two age groups of different gender (female & male 30 - 40 years and female & male

60 - 70 years) were examined again.

To compare the difference of the End point Excursion between the two age groups (female & male age 30 – 40 years and female & male age 60 - 70 years), the ability to reach targets in single movement towards the Forward, Right Forward, Right Backward and Left Backward directions are reduced more than any other directions.

To compare the difference of the Maximum Excursion between the two age groups (female & male age 30 – 40 years and female & male age 60 -70 years).The Forward, Backward, Right Backward, and Left Backward are the directions that subjects have reduced their maximum movement more than any other directions.

Conclusion

This study demonstrates that age has more effect than gender are influencing postural stability and dynamic balance in Thai community dwelling adults. As elderly people have the ability to reach especially in the forward direction less than the younger group.

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