

Normative Value of Oblique Direction Reach Test in Healthy Adults Ages 50-80 Years: An Observational Study.

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Abstract: *Background:* Balance and postural stability are essential for functional independence in daily activities, especially in older adults. While forward and lateral stability limits are well established, diagonal (oblique) reach directions more closely reflect real-life movements. However, normative reference values for the Oblique Direction Reach Test (ODRT) in older adults are not studied enough. Objective of this study: To establish normative values for the ODRT in healthy adults aged 50–80 years and to find the relationship between ODRT performance and age, gender, height, and BMI. Methods: 120 healthy adults (60 males, 60 females) aged 50–80 years were recruited and they were divided into three age groups (50–59, 60–69, 70–79 years). ODRT was administered bilaterally in the anterior-oblique direction using standardized procedures. Each participant performed three valid trials, and mean reach distance (cm) was recorded. Descriptive statistics were computed, normality was checked with the Shapiro–Wilk test, and Pearson correlation was used to assess associations between variables. Results: The overall mean $\pm$ SD ODRT reach distance was 18.65 ± 6.25 cm for right hand and 17.88 ± 6.89 cm for left hand. Males showed significantly greater ODRT than females ($p < 0.001$) in this age group, further a progressive decline in ODRT with increasing age. Conclusion: This study provides the first normative reference values for ODRT performance in healthy adults aged 50–80 years. It confirmed that ODRT declines with age and differs by gender. These findings can serve as clinical reference values for assessing dynamic balance and limits of stability in older adults aged 50-80 years.

Keywords: Oblique Direction Reach Test, Balance, Elderly, Limits of Stability, Normative Values.

INTRODUCTION

Harmonizing the forces operating on the body results in balance, which keeps the centre of mass (COM) within the stability bounds indicated by the base of support (BOS).¹ The ability to effectively manage the pressure centre (COP) both inside and outside the BOS while coordinating several body parts to perform motions involving multiple joints is known as balance. Maintaining both static and dynamic postural control is crucial for performing daily tasks.² Static postural control consists of keeping the centre of mass in the support system motionless without moving any body parts, whereas dynamic postural control involves moving the centre of gravity and body parts within stable constraints to perform tasks like reaching for objects.³

The complex act of maintaining balance necessitates combining input from higher brain functions with data from multiple body systems, including the vestibular system, somatosensory perception, the musculoskeletal

system, and eyesight. Cognitive and musculoskeletal systems, as well as visual, vestibular, and somatosensory inputs, change physiologically as people age.⁴ Age and balance are correlated when age is raised in accordance with declining balance control. Additionally, as people age, their musculoskeletal, peripheral, and central neurological systems alter, resulting in diminished muscle mass, strength, and flexibility, agility, and speed and their postural sway increases.⁵

Impaired postural stability can result from several age-related neurological conditions, including "stroke, multiple sclerosis, traumatic spinal cord damage, traumatic brain injury (TBI), Parkinson's disease (PD), cerebral palsy (CP)," as well as diseases of the cerebellum, muscular dystrophy, and IQ deficiencies. Reduced mobility from inadequate postural stability raises the risk of falls and impairs the daily performance of activities, including reaching, lifting, and leaning.⁶

A wide range of instruments, tests, and scales is available to measure handicap due to imbalance. Known for its complexity and expense, the computerised force platform is the gold standard for evaluating balance impairment. In the clinical context, a number of metrics are used to evaluate balance from a functional standpoint. It can take a lot of time to administer the Timed Up and Go Test (TUG), Performance-Oriented Mobility Assessment, Berg Balance Scale (BBS), Lateral Reach Test (LRT), Functional Reach (FRT), Balance Evaluation Systems Test, and Postural Assessment Scale to each individual, and not all elderly people will benefit equally from them.^{7,8}

Among the simple alternatives for measuring balance when analyzing balance objectively in terms of stability limitations are LRT, FRT, and the Multidirectional Reach Test (MDRT). Accessibility initially looked at the FRT. They offer reliable, valid results and are simple to use. In 1990,

Duncan et al. presented a method for examining the forward direction's margin of stability.⁹ To assess balance performance, Brauer et al. developed the LRT, a clinical test, in 1999. This exam evaluates a person's sideways body steering skills while maintaining a steady base of support.¹⁰ Forward, backward, right, and left are the four directions in which MDRT evaluates a person's COM movement ability.¹¹

However, reaching is not always done in a forward or lateral manner in daily activities. While doing activities in and around the house, office, or during sporting events, the reach is typically diagonal. The stability limits of computerized dynamic posturography were examined in a study conducted by Liaw MY et al. on 107 healthy participants. In contrast to lateral and forward directions, they discovered that oblique (right and left forward) directions had less control over direction and reaction time.¹² The study by Ganesan et al. examined the limits of stability in eight directions in both multiple sclerosis patients and healthy controls. They noticed a decrease in reaction time and direction control in the diagonal direction compared to the forward and lateral reach directions.¹³ According to a study on patients with chronic stroke, reaching in the oblique direction was more hampered, and the affected side had the least amount of pressure center movement in the backward lateral direction.¹⁴

The ODRT evaluates a person's capacity to move their center of gravity away from the base of support in an oblique direction without assistance or movement. Reaching is most helpful when done obliquely rather than forward or laterally, as in the case of running an elevator, using kitchen equipment, reaching for shelves, eating with a fork, performing desk work, and going to sporting events.⁶

The ODRT assesses an individual's dynamic balance and limits of stability (LOS). Tedla et al. developed ODRT in 2020, and in healthy individuals, each rater's reliability both within and between participants was found to be exceptional, with ICC values of 0.97 and 0.856. The forward and lateral reach tests were also used in concurrent validity research by R. Mascarenhas et al., who found intra-rater and inter-rater reliabilities in the stroke population with ICCs of 0.997-0.996 and R-values of 0.78 and 0.73. The ODRT's remarkable psychometric properties were proved by Tedla et al.'s normative investigation in a healthy age group of kids and teenagers (6–12 years).^{3,6,15}

There are reference values for determining the stability and balance impairment bounds in the front, side, and rear orientations. However, the literature also suggests that understanding the stability boundaries in a diagonal orientation is crucial for daily living. In order to properly assess, monitor, and address postural control and balance disorders across various age groups, healthcare providers might benefit from knowing the normative values. Nevertheless, there are no ODRT reference values available for evaluating LOS and balance in healthy persons.

The study aimed to determine the normative value in healthy adults aged 50-80 years. The objectives of the study were to establish the reference values of the ODRT in healthy elderly adults, to determine normative values across different age groups ranging to the elderly population, to compare ODRT performance between genders, and to examine the correlation of ODRT reach distance with demographic and anthropometric variables such as weight, height, body mass index (BMI), and age among healthy elderly adults aged 50-80years.

MATERIALS AND METHODOLOGY:

The observational study was done between March 2024 and July 2025. A sample size calculation was first performed using a pilot study with 12 participants ($M = F$) at a 95% confidence level and 90% power. Sample size is calculated using the formula of $n = 2 \left(\frac{Z_{\alpha} + Z_{\beta}}{d} \right)^2 \frac{S^2}{d^2}$. Where $Z_{\alpha} = 1.96$ at 95% confidence level and $Z_{\beta} = 1.28$ at 90% power, S Combined standard deviation, and d is the Mean difference with 95% confidence level and 90% power to the pilot study outcome, where Mean difference $d = 6.0$ and Standard deviation = 6.5, sample size, so the sample size was calculated 120. Age between 50 years to 80 years, 120 healthy elderly adults were included as per the inclusion criteria. Males and females are both included. Participants who have any underlying neurological conditions (Stroke, Parkinson's disease, DNP, etc), cardiovascular conditions, and musculoskeletal conditions (fracture, pain in the shoulder, back, muscular weakness, etc), or any history of back and lower extremity surgery, Structural deformities, Visual and vestibular disorders (diabetic

radiculopathy, cataract, glaucoma, age-related muscular degeneration, etc.), Limb length discrepancy (more than 1.5 to 2 CMS), History of Abdominal surgery were excluded in this study. Ethical approval was obtained from the institutional ethical committee. Participants were provided written informed consent. Demographic data such as gender, age, height, weight, BMI, and hand dominance were collected from all participants. All the

participants were thoroughly briefed about the procedure, and then they were asked to perform the tests with the instructions given by the tester. The testing procedures were performed by a qualified physiotherapist who was pursuing her masters in Neurosciences and practising physiotherapy. This study followed declaration of Helsinki 2013 for human research.

PROCEDURE

The oblique direction reach test was assessed with a tripod stand holding a ruler at the degree of each participant's acromion process, and they stood with their shoulders apart at the toes and barefoot. The ruler was positioned at a 45-degree angle between the lateral and anterior directions, marked on the floor with tape. Participants were instructed to raise their right arm to a 90-degree angle in the oblique anterior-lateral direction, aligning it parallel to the ruler. The beginning location was marked with a pencil mark on the ruler at the point of the third metacarpal. Then, without shifting their feet, touching the ruler, bending their knees, or raising their heels, they extended as far as they could in an oblique manner, keeping their contact with it for two to three seconds. The terminal point was indicated on the ruler by another pencil mark at the tip of the third metacarpal. The two markings' separation was expressed in centimetres.

STATISTICAL ANALYSIS:

Analytical statistics were conducted using IBM SPSS Statistics for Windows, version 25.0. The normality of the data was assessed using the Shapiro-Wilk test. Demographic data and reference values were expressed as mean $\pm$ standard deviation. Based on the distribution of the data which was normal, Pearson's correlation coefficient was used to examine the relationship between age, gender, and the ODRT outcomes. A significance level of $p \leq 0.05$ was considered statistically significant. Every participant finished three real trials after completing a practice trial; the mean distance was then recorded for analysis.

RESULTS:

Descriptive statistics were used to analyze the demographic characteristics, including height, weight, and BMI. The mean $\pm$ SD values for these variables are presented for 120 healthy adults across gender and age subgroups ranging from 50 to 79 years (see Table 1).

Table 1: Descriptive values of demographic characteristics (n=120)

F= Female, M= Male, BMI = Body Mass Index

Age	Gender	n	Height (cm)	Weight (kg)	BMI (kg/m ²)
50-59	F	25	156.30 $\pm$ 11.99	60.74 $\pm$ 12.12	24.95 $\pm$ 4.48
	M	25	170.27 $\pm$ 8.99	66.06 $\pm$ 10.13	22.91 $\pm$ 4.09
60-69	F	25	155.02 $\pm$ 12.79	59.56 $\pm$ 9.83	25.20 $\pm$ 4.51
	M	25	169.45 $\pm$ 6.72	67.74 $\pm$ 9.02	23.59 $\pm$ 2.82
70-79	F	10	153.65 $\pm$ 8.62	53.05 $\pm$ 8.24	22.63 $\pm$ 4.51
	M	10	164.76 $\pm$ 7.97	64.38 $\pm$ 5.67	23.90 $\pm$ 3.54

Table 2: ODRT difference according to gender and age (right-hand)

Age	Gender	Minimum Right (cm)	Maximum Right (cm)	ODRT Right hand DIFFERENCE
50-59	F	11.30	24.80	19.75 $\pm$ 3.46
	M	10	35.30	19.82 $\pm$ 6.16

60-69	F	10.20	27.30	18.83±3.98
	M	8	33	20.72±6.31
70-79	F	6	17.70	12.56±3.27
	M	8.50	23.10	16.76±4.46
Total	F	6	27.30	19.69±6.05
	M	8	35.50	17.61±6.33
	Both	6	35.50	18.65±6.25

Table 3: ODRT difference according to gender and age (left-hand)

Age	Gender	Minimum Left (cm)	Maximum Left (cm)	ODRT Left hand DIFFERENCE
50-59	F	5.60	54.80	20.17±8.63
	M	8	35.00	19.84±5.70
60-69	F	9	26.50	17.24±4.97
	M	2	30.80	17.36±7.92
70-79	F	8.60	18.20	13.34±3.04
	M	7.50	19.30	15.45±3.76
Total	F	5.60	54.80	17.95±6.94
	M	2	35.00	17.81±6.91
	Both	2	54.80	17.88±6.89

Table 4: Correlation between age and ODRT in cm (n=120)

Age	Pearson Correlation (r value)	-.217*	-.252**
	Sig. (2-tailed)	.017	.005
*. Correlation is significant at the 0.05 level (2-tailed).			
**. Correlation is significant at the 0.01 level (2-tailed).			

There was highly negative correlation between age and ODRT distance in cm. There was gradual decline in ODRT distance in cm when age increases. Karl Pearson correlation test was used to calculate the correlation (see Table 4).

DISCUSSION:

The present study established normative values for the ODRT among healthy adults aged 50–80 years. The findings revealed that men exhibited significantly greater reach distances than women, and reach performance declined with increasing age. These results align with previous findings on the age-related decline in postural stability and functional reach.

The observed gender difference may be attributed to greater height, limb length, and muscle strength in males, which are known to enhance the displacement of the center of mass (COM) during dynamic balance tasks.

Similar results were reported by Tedla et al. (2020), who demonstrated excellent reliability of ODRT and noted the influence of anthropometric variables on reach distance. Moreover, Ganesan et al. found that diagonal or oblique directions pose greater postural challenges than purely forward or lateral directions, suggesting that the ODRT captures balance demands more representative of daily functional activities.

The progressive reduction in reach distance with advancing age observed in this study supports earlier reports indicating that neuromuscular, sensory, and cognitive systems deteriorate with aging, leading to

reduced flexibility, muscle strength, and reaction time (Liaw et al.; Brauer et al.). This decline in oblique reach may also reflect the reduced ability to integrate multisensory feedback and maintain center of pressure (COP) control beyond the base of support.

Interestingly, while height showed a positive correlation with ODRT distance, BMI demonstrated a mild negative correlation, consistent with studies showing that higher BMI limits dynamic postural adjustments due to altered biomechanics and greater inertia.

From a clinical perspective, these normative data provide valuable benchmark values for assessing and monitoring dynamic balance performance in older adults. The ODRT, being a simple, cost-effective, and reliable measure, may complement conventional assessments like the Functional Reach Test (FRT) and Lateral Reach Test (LRT), offering additional insight into diagonal stability limits—movements frequently used in activities such as reaching across a table or operating kitchen equipment.

Limitations of this study:

The study was limited to healthy adults from a single region, which may restrict generalizability. Factors such as occupation, physical activity level, and limb length were not controlled.

Future recommendations of this study:

Future research should investigate ODRT performance in individuals with neurological or musculoskeletal impairments (e.g., stroke, Parkinson's disease, or multiple sclerosis) to establish diagnostic and prognostic reference values. Longitudinal studies could also examine how training or exercise interventions influence ODRT outcomes over time.

CONCLUSION

This study provides the first normative reference values for ODRT performance in healthy adults aged 50–80 years. It confirmed that ODRT declines with age and differs by gender. These findings can serve as clinical reference values for assessing dynamic balance and limits of stability in older adults aged 50-80 years.

Ethical committee approval:

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Credit authorship contribution statement

- Author 1: Conceptualized the study, involved in formal analysis, designed methodology, wrote the original draft, and administered the project.
- Author 2: Conceptualized the study; investigated the study; wrote the original draft; wrote, reviewed, and edited the manuscript; and supervised the project.
- Author 3: Involved in formal analysis, collected data, designed methodology, and investigated the data.
- Author 4: Conceptualized the study; edited the manuscript; and supervised the project.
- Author 5: Involved in formal analysis, collected data, and investigated the data.

All authors read and approved the final version of the manuscript.

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