EFFECT OF UPPER LIMB DOMINANCE ON FUNCTIONAL REACH TEST PERFORMANCE IN HEALTHY YOUNG ADULTS: A PILOT CROSS - SECTIONAL STUDY

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ABSTRACT:
Background: The Functional Reach Test (FRT) is a simple, valid, and reliable clinical measure of dynamic balance and anticipatory postural control. Although a variety of factors have been determined to affect FRT performance, the impact of upper limb dominance on forward reach distance has not been sufficiently investigated. Determining whether hand dominance influences FRT performance may help clarify the interpretation of assessments of unilateral balance and provide initial normative data for young adults in good health.
Methods: A pilot cross-sectional observational study was conducted among 21 healthy young adults aged 17 to 21 years. A standard procedure was used to evaluate Functional Reach Test (FRT) performance. For both the dominant and non-dominant upper limbs, three trials were performed; statistical analysis was conducted using the average of the three trials. Anthropometric and demographic characteristics were summarized using descriptive statistics. The dominant and non-dominant upper limbs' FRT performance was evaluated using a paired t-test. FRT performance was compared by gender and hand dominance using independent-samples t-tests, and the association between anthropometric factors and FRT performance was evaluated using Pearson's correlation coefficient. Statistical significance was set at $p < 0.05$.
Results: A total of 21 healthy young adults (11 females and 10 males) participated in the study. The average non-dominant FRT distance was 29.83 ± 5.58 cm, while the average dominant FRT distance was 31.18 ± 5.91 cm. When using their dominant upper limb instead of their non-dominant upper limb, participants performed considerably better on the Functional Reach Test ($p = 0.018$). Gender and hand dominance did not significantly affect FRT performance ($p > 0.05$). While height and upper limb length did not significantly correlate with FRT performance, there was a considerable positive connection ($r = 0.69$, $p < 0.001$) between dominant and non-dominant FRT performance.
Conclusion: Although the difference was very little, healthy young adults performed noticeably better on the Functional Reach Test when using their dominant upper limb as opposed to their non-dominant upper limb. Therefore, upper limb dominance should be taken into account during clinical interpretation as it may affect unilateral Functional Reach Test performance. These results offer initial proof that more extensive, multicenter research is necessary to determine normative reference values and explore the impact of upper limb dominance on dynamic balance.

Keywords: *Dynamic balance, Functional Reach Test, Hand dominance, Postural control, Upper limb dominance.*

INTRODUCTION: Dynamic balance is the ability to voluntarily move the body while maintaining postural stability within the limits of stability. It is a key component of functional mobility and is essential for performing activities of daily living, occupational tasks, and sports-related activities. Effective dynamic balance requires the coordinated interaction of the visual, vestibular, and somatosensory systems, together with efficient neuromuscular control and anticipatory postural adjustments. Impairments in these systems may adversely affect postural stability, reduce functional performance, and increase the risk of falls and musculoskeletal injuries.[1,2]

Assessment of dynamic balance is an important component of physiotherapy practice. Several clinical outcome measures are available to evaluate balance, including the Berg Balance Scale, Timed Up and Go Test, Star Excursion Balance Test, Y-Balance Test, and Functional Reach Test (FRT). The Functional Reach Test measures the maximum distance an individual can voluntarily reach forward while maintaining a fixed base of support without taking a step or losing balance. It is widely used in neurological, geriatric, musculoskeletal, and sports rehabilitation and reflects an individual's limits of stability, anticipatory postural control, and dynamic balance. [3] Recent advances in sensor-based technologies have further improved the objectivity and accuracy of Functional Reach Test measurements while maintaining the clinical relevance of the conventional assessment protocol. [4]

Several factors, including age, muscle strength, trunk stability, flexibility, physical activity level, and anthropometric characteristics, have been reported to influence Functional Reach Test performance. [5] However, limited research has investigated the influence of upper limb dominance on Functional Reach Test performance. The dominant upper limb generally demonstrates superior motor control, proprioception, coordination, and movement precision because of its frequent use during daily functional activities. These neuromuscular adaptations may influence forward reach performance and should therefore be considered while interpreting unilateral balance assessments. [6].

NEED OF THE STUDY: Although the Functional Reach Test is widely used in clinical practice, there is limited evidence comparing Functional Reach Test performance between the dominant and non-dominant upper limbs in healthy young adults. Determining whether upper limb dominance influences Functional Reach Test performance may improve the interpretation of unilateral balance assessments and provide preliminary normative data for healthy young adults. Therefore, the present pilot study was undertaken to compare Functional Reach Test performance between the dominant and non-dominant upper limbs in healthy young adults using a standardized assessment protocol.

AIM: To compare functional reach distance between the dominant and non-dominant upper limbs in healthy young adults.

OBJECTIVES:

1. To assess Functional Reach Test (FRT) performance using the dominant upper limb in healthy young adults.
2. To assess Functional Reach Test (FRT) performance using the non-dominant upper limb in healthy young adults.
3. To compare Functional Reach Test (FRT) performance between the dominant and non-dominant upper limbs.
4. To compare Functional Reach Test (FRT) performance according to gender and hand dominance.
5. To determine the relationship between anthropometric variables (height and upper limb length) and Functional Reach Test (FRT) performance.

MATERIALS AND METHODS:

Study Design: A pilot cross-sectional observational study.
Study Setting: Department of Sports Physiotherapy, Maharashtra Institute of Physiotherapy, Latur, Maharashtra, India.
Study Population: Healthy young adults studying at Maharashtra Institute of Physiotherapy.
Sample Size: 21 healthy young adults.
Study Duration: One month.
Sampling Technique: Convenience sampling.

Materials Required:

- Measuring tape (graduated in centimeters).
- Wall mounted measuring scale.
- Masking tape.
- Marker pen.
- Data recording sheet.
- Consent form.
- Pen.

ELIGIBILITY CRITERIA:

Inclusion Criteria:

- Healthy individuals aged 17 to 25 years.
- Both male and female participants.
- Ability to stand independently without external support.
- Willingness to participate and provide written informed consent.

Exclusion Criteria:

- History of neurological disorders.
- History of musculoskeletal injury involving the upper or lower limbs within the previous six months.
- Balance or vestibular disorders.
- Inability to understand study instructions.

OUTCOME MEASURE: Functional Reach Test (FRT): The Functional Reach Test was used to assess dynamic balance. The FRT measures the maximum distance an individual can voluntarily reach forward beyond arm's length while maintaining a fixed base of support without taking a step or losing balance. Reach distance was recorded in centimeters (cm).

Variables Recorded: The following demographic and anthropometric variables were recorded:

- Age (years).
- Gender.
- Height (cm).
- Right arm length (cm).
- Left arm length (cm).
- Functional Reach Test distance (Dominant Upper Limb).
- Functional Reach Test distance (Non-dominant Upper Limb).

PROCEDURE: After obtaining informed consent, each participant underwent a standardized assessment. Demographic data, including age, gender, height, upper limb length, and hand dominance, were recorded. Hand dominance was determined by asking participants which hand they primarily used for writing and performing most activities of daily living. For the Functional Reach Test (FRT), participants stood barefoot beside a wall with their feet positioned shoulder-width apart. They were instructed to maintain their feet in a fixed position throughout the test without lifting or moving them. A horizontal measuring tape was securely attached to the wall at the level of the participant's acromion process to facilitate accurate measurement of the reaching distance. Participants were instructed to raise the test arm to 90° of shoulder flexion while maintaining full elbow extension, forearm pronation, a neutral wrist position, and fully extended fingers. The examiner aligned the distal end of the third metacarpal with the measuring tape and recorded the initial position. Participants were then instructed to "Reach forward as far as possible without taking a step, lifting your heels, or losing your balance." During the test, stepping, heel lift, and trunk rotation were not permitted. At the point of maximal forward reach, the final position of the distal end of the third metacarpal was recorded. The functional reach distance was calculated as the difference between the initial and final measurements.

Each participant completed three trials using the dominant upper limb, followed by three trials using the non-dominant upper limb. A 30-second rest interval was provided between consecutive trials to minimize fatigue. For statistical analysis, the mean value of the three trials for each upper limb was used.

STATISTICAL ANALYSIS: The collected data were entered into Microsoft Excel and analyzed using SPSS Software 25.0. Continuous variables were summarized using mean and standard deviation (Mean ± SD), whereas categorical variables were expressed as frequencies and percentages. Normality of the data was assessed using the Shapiro - Wilk test. Since the data were normally distributed: A paired t-test was used to compare dominant and non-dominant Functional Reach Test distances. Independent sample t-tests were performed to compare reach distances between males and females and between right and left hand dominant participants. Pearson's correlation coefficient was used to determine the relationship between anthropometric variables (height and arm length) and Functional Reach Test performance. A 95% confidence interval was used for all statistical analyses. The level of statistical significance was set at $p < 0.05$.

RESULTS: Participant Characteristics: A total of 21 healthy young adults participated in this pilot study. All participants successfully completed the Functional Reach Test protocol, and no missing data or adverse events were recorded. The study sample consisted of 11 females (52.4%) and 10 males (47.6%). Participants ranged in age from 17 to 21 years, with a mean age of 19.33 ± 1.20 years. The mean height was 166.76 ± 7.70 cm. Fifteen participants (71.4%) were right-hand dominant, whereas six participants (28.6%) were left-hand dominant.

Variable	Mean ± SD / n (%)
Age (years)	19.33 ± 1.20
Height (cm)	166.76 ± 7.70
Right Arm Length (cm)	73.86 ± 5.80
Left Arm Length (cm)	73.79 ± 5.38
Females	11 (52.4%)
Males	10 (47.6%)
Right-hand dominant	15 (71.4%)

Left-hand dominant	6 (28.6%)

Table 1. Demographic and Anthropometric Characteristics of Participants (N = 21)

Functional Reach Test Performance: The mean dominant Functional Reach Test distance was 31.18 ± 5.91 cm, whereas the mean non-dominant reach distance was 29.83 ± 5.58 cm. The mean paired difference between dominant and non-dominant reach distances was 1.35 cm, indicating a slightly greater reach on the dominant side.

Variable	Mean ± SD (cm)	Minimum	Maximum
Dominant Reach	31.18 ± 5.91	22.10	45.00
Non-dominant Reach	29.83 ± 5.58	19.00	40.30
Mean Difference	1.35	—	—

Table 2. Functional Reach Test Performance

Comparison Between Dominant and Non-Dominant Reach Distance: A paired-samples t-test was performed to compare Functional Reach Test performance between the dominant and non-dominant upper limbs. Participants demonstrated significantly greater reach distance with the dominant upper limb (Mean difference = 1.35 cm; 95% CI: 0.25 to 2.45 cm; t(20)=2.57; p=0.018). The standardized effect size was Cohen's d = 0.56, indicating a moderate effect.

Variable	Mean ± SD (cm)	Mean Difference	95% CI	t(df)	p-value	Cohen's d
Dominant Reach	31.18 ± 5.91					
Non-dominant Reach	29.83 ± 5.58	1.35	0.25–2.45	2.57 (20)	**0.018**	0.56

Table 3. Comparison Between Dominant and Non-Dominant Reach Distance

Comparison According to Sex: Female participants demonstrated a mean dominant reach distance of **31.46 ± 5.67 cm**, whereas male participants demonstrated **30.87 ± 6.40 cm**. The mean non-dominant reach distance was **30.51 ± 5.78 cm** among females and **29.09 ± 5.48 cm** among males. Independent-samples t-tests revealed no statistically significant differences between males and females for either dominant or non-dominant reach distances. No statistically significant sex-related differences were observed.

Variable	Female (n=11)	Male (n=10)	t(df)	p-value
Dominant Reach (cm)	31.46 ± 5.67	30.87 ± 6.40	0.22 (19)	0.825
Non-dominant Reach (cm)	30.51 ± 5.78	29.09 ± 5.48	0.58 (19)	0.568

Table 4. Comparison According to Gender

Comparison According to Hand Dominance: Among right-handed participants, the mean dominant reach distance was **30.92 ± 6.37 cm**, whereas left-handed participants demonstrated **32.03 ± 4.61 cm**. Similarly, non-dominant reach distance averaged **28.87 ± 5.55 cm** in right-handed participants and **32.67 ± 4.17 cm** among left-handed participants. Independent-samples t-tests revealed no statistically significant differences between right- and left-handed individuals.

Variable	Right-handed (n=15)	Left-handed (n=6)	t(df)	p-value
Dominant Reach	30.92 ± 6.37	32.03 ± 4.61	-0.39 (19)	0.700
Non-dominant Reach	28.87 ± 5.55	32.67 ± 4.17	-1.52 (19)	0.145

Table 5. Functional Reach Performance According to Hand Dominance

Correlation Analysis: Pearson correlation analysis demonstrated a strong positive correlation between dominant and non-dominant reach distances ($r = 0.69$, $p < 0.001$), indicating that participants who demonstrated greater reach on the dominant side also tended to demonstrate greater reach on the non-dominant side. No statistically significant correlations were observed between anthropometric variables and Functional Reach Test performance. Height demonstrated weak positive correlations with dominant ($r = 0.18$) and non-dominant ($r = 0.19$) reach distances. Similarly, right and left arm lengths showed negligible associations with reach performance.

Variables	Pearson's r	p-value	Interpretation
Height vs Dominant Reach	0.18	0.431	Weak positive
Height vs Non-dominant Reach	0.19	0.407	Weak positive
Right Arm Length vs Dominant Reach	0.02	0.928	Negligible
Left Arm Length vs Non-dominant Reach	-0.09	0.704	Negligible
Dominant vs Non-dominant Reach	**0.69**	**<0.001**	Strong positive

Table 6. Pearson Correlation Analysis

DISCUSSION: The Functional Reach Test (FRT) performance of healthy young individuals' dominant and non-dominant upper limbs was compared in the current pilot study. The results showed that the dominant upper limb produced noticeably better FRT performance than the non-dominant upper limb. However, anthropometric factors were not substantially linked to FRT performance, and neither sex nor hand dominance showed any discernible differences. The results of the Functional Reach Test showed good bilateral consistency, with a strong positive correlation between dominant and non-dominant reach distances.

Dominant versus Non-Dominant Functional Reach Performance - The study's main conclusion was that, with a mean difference of 1.35 cm, subjects performed noticeably better on the Functional Reach Test using their dominant upper limb. The amount of this difference was quite tiny, despite being statistically significant, indicating that forward reach performance in young adults in good health is only slightly impacted by upper limb dominance. A commonly used clinical tool for assessing dynamic balance, anticipatory postural control, and stability limits is the Functional Reach Test. Its validity, reliability, and clinical utility in a range of clinical populations and healthy persons have been emphasized in recent research. [8,9] The stronger neuromuscular control of the dominant upper limb may account for the dominant-side advantage seen in this study. It may improve motor planning, proprioception, and movement efficiency to frequently employ the dominant arm during tasks requiring coordination, precision, and object manipulation. [1] Forward reaching in the Functional Reach Test necessitates synchronized shoulder, trunk, pelvic, and lower limb movements while preserving postural stability. Therefore, improved neuromuscular coordination of the dominant upper limb may allow people to more effectively approach their limits of stability without sacrificing balance. Although direct comparisons between dominant and non-dominant upper limb Functional Reach Test performance are limited, the present findings suggest that upper limb dominance should be considered when interpreting

unilateral Functional Reach Test assessments. Nevertheless, the relatively small mean difference indicates that healthy young adults maintain effective bilateral postural control, thereby minimizing clinically meaningful asymmetry. [2]

Influence of Gender - Male and female participants did not significantly differ in their performance on the Functional Reach Test. Males tend to have more muscle mass and upper limb strength, but dynamic balance and postural control are more important factors in Functional Reach Test performance than just maximal muscle strength. These results imply that, in healthy young adults with intact balance mechanisms, sex alone may not significantly affect Functional Reach Test performance. Additionally, prior research has shown that a variety of biomechanical and neuromuscular factors, rather than just sex, affect Functional Reach Test results. [7]

Influence of Hand Dominance - Relationship Between Anthropometric Variables and Functional Reach Performance: Participants who were left-handed and right-handed did not significantly differ from one another. The mean reach distances of left-handed participants were somewhat higher, but these differences were not statistically significant. These results suggest that overall performance on the Functional Reach Test may not be significantly impacted by the direction of hand dominance. Regardless of whether they are left-handed or right-handed dominant, healthy people seem to be able to use comparable postural control techniques. However, these results should be interpreted cautiously because just six individuals in the current study were left-hand dominant. [8]

Correlation Between Dominant and Non-Dominant Reach Performance - Dominant and non-dominant Functional Reach Test distances showed a significant positive connection. Individuals who were able to reach farther with their dominant upper limb also tended to reach farther with their non-dominant upper limb. This result confirms the reproducibility of the Functional Reach Test when conducted using standardized techniques and shows good bilateral consistency in dynamic balancing performance among young adults in good health. [9]

CLINICAL IMPLICATIONS: Although the dominant-side advantage was small, clinicians should consider upper limb dominance when interpreting unilateral Functional Reach Test performance, as side-to-side differences of approximately 1–2 cm may represent normal variation in healthy young adults. These findings may aid clinical assessment and provide preliminary evidence for future studies on upper limb dominance and normative reference values.

LIMITATIONS:

1. The study was conducted with a relatively small sample size as a pilot investigation, which may limit the generalizability of the findings.
2. Participants were recruited from a single institution using convenience sampling; therefore, the results may not be representative of the broader population of healthy young adults.
3. The study included a smaller number of left-hand dominant participants compared to right-hand dominant participants, which may have reduced the statistical power for comparisons based on hand dominance.
4. Only healthy young adults were included in the study. Therefore, the findings cannot be generalized to older adults or individuals with neurological, musculoskeletal, or balance impairments.
5. Functional Reach Test performance was assessed using a clinical measurement technique. Instrumented assessment methods, such as motion analysis or wearable sensor-based systems, were not used and may provide additional information regarding movement strategies and postural control.

CONCLUSION: In healthy young individuals, this pilot investigation showed considerably better Functional Reach Test (FRT) performance with the dominant upper limb than the non-dominant upper limb, indicating that upper limb dominance may affect unilateral FRT performance. Anthropometric factors were not linked to FRT performance, and neither sex nor hand dominance showed any significant differences. Good bilateral consistency was demonstrated by a high positive correlation between dominant and non-dominant reach distances. These results demonstrate the need for larger multicenter investigations to establish normative reference values and offer preliminary evidence confirming the impact of upper limb dominance on FRT performance.

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