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Influence of Hip Mobility and Strength on Gait Parameters among Young Females—A Cross-Sectional Study

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Abstract

Background The hip's primary function is to dynamically support the weight of the trunk while allowing the force and load transmission axial skeleton to the lower extremity and henceforth allowing mobility. The function of the hip is not only to take the load of the trunk to the lower extremity but also to perform daily activities which include walking, running, jumping, sitting, etc. Hip muscle strength is required to stabilize the pelvic and trunk during squatting and walking (single stance) and to perform other daily living activities. The prevalence rate reports that males are more physically active than females. The number of physical activities has shown to be decreased in teens and young adults between the ages of 14 and 22 years due to transitions in their lifestyle. These changes can be behavioral and due to body composition. The objectives of the study are to determine the influence of hip mobility and strength on the spatial and temporal parameters of gait.

Methodology This is a cross-sectional study involving a total of 50 young female populations that have been selected based on the inclusion criteria. Hip range of motion using a universal goniometer was measured in three trials with 30 seconds of rest between each measurement. The hip muscle strength was measured using a handheld dynamometer with 5 seconds hold and three trials taking 30 seconds of rest between each measurement. Spatial parameters of gait were measured by using Kinovea software V.0.8.15, and temporal parameters of gait were measured by asking the subject to walk comfortably in their own speed for 1 minute and the video was taken and measured.

Result The hip internal rotation and external rotation has shown to have a statistical significance with spatial and temporal parameters of gait. The hip abductors, adductors, internal rotators, and external rotator muscle strength have shown to have statistical significance with spatial and temporal parameters of gait. Descriptive statistics were used for demographic characteristics, and Pearson's correlation coefficient is used for determining association between outcome variables.

Conclusion The hip abductors, adductors, internal rotators, and external rotators have shown to have influence on gait parameters specially with walking speed. The hip internal and external rotation has shown to have influence on gait parameters.

Keywords
- influence
- hip mobility
- muscle strength
- parameters of gait

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Introduction

The hip joint plays a crucial role in supporting the weight of the trunk and facilitating lower extremity movement during daily activities such as walking, running, and jumping. With six degrees of freedom, the hip joint allows for a range of motion (ROM), including flexion, extension, abduction, adduction, internal rotation, and external rotation. However, reduced physical activity, particularly in the young female population, can lead to restricted hip mobility and strength, which may impact lower limb mechanics.[1]

Studies have primarily focused on the knee component of mobility and strength, but few have examined the young female population's hip component. Understanding the impact of hip mobility and strength on gait parameters can help predict an individual's health status and identify interventions to improve hip ROM and muscle strength.[2]

Reduced physical activity and sedentary lifestyles in young women can cause altered body structure and mechanics, leading to kinematic and kinetic changes in the lower limb. The Osteoarthritis Research Society International has recommended gait parameters as predictors of an individual's health status. Hence, it is essential to examine the hip joint's impact, as changes in the hip joint can affect the knee joint and vice versa.[3]

Hip muscle strength is crucial for stabilizing the pelvis and trunk during squatting and walking, and the gluteus medius muscle primarily prevents hip drop during femur rotation. Therefore, even slight weakness of the gluteus muscle can cause deviations in standing and walking. Gait parameters such as stride length, step length, cadence, stride time, step time, and walking speed require hip ROM and strength. Any restricted hip mobility can lead to decreased muscle strength, further impacting gait parameters.[4,5]

This study aims to bridge the gap in the existing literature by examining the influence of hip mobility and strength on gait parameters among sedentary young females. Identifying the impact of hip mobility and strength on gait parameters can lead to interventions to improve hip ROM and muscle strength, leading to better lower limb mechanics and overall health outcomes.

Materials and Methods

This study was designed as a cross-sectional study. The participants were young female students of NITTE Institute of Physiotherapy, NITTE (deemed to be university), Deralakatte, Mangaluru, Karnataka, India. The inclusion criteria for the study were females aged between 17 and 22 years, with the ROM less than 35 degrees for both internal and external rotation as a cutoff identified by goniometer and hip muscle tightness. The exclusion criteria were females with low back pain, hip, knee and ankle pain, previous knee, hip surgeries, hip joint, knee joint, and ankle deformities and pathology, and flat foot. Ethical clearance for the proposed study was obtained from NITTE Institute of Physiotherapy's Institutional Ethics Committee, Mangaluru.

Hip ROM for flexion, extension, abduction, adduction, and internal and external rotation was taken by a goniometer. The strength of the hip muscle flexor, extensor, abductor,

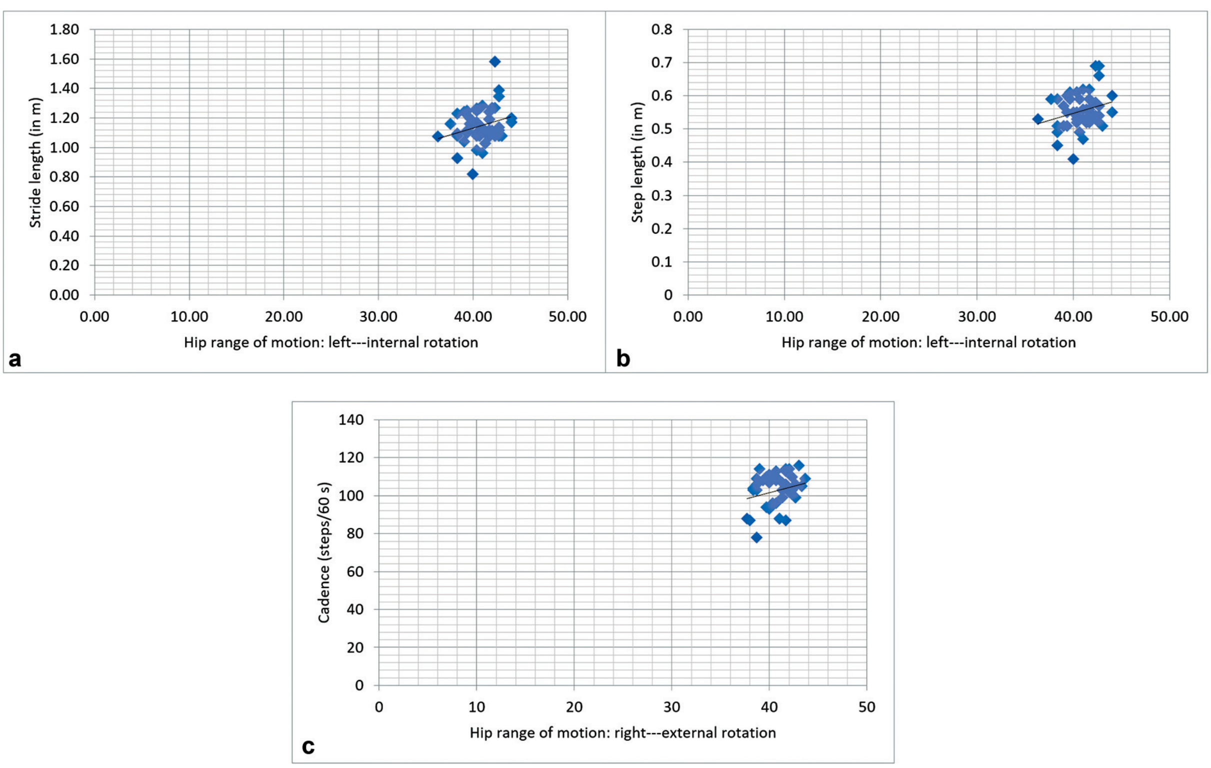

Fig. 1 (**a**) Correlation between left internal rotation rom and stride length. (**b**) Correlation between left internal rotation rom and step length. (**c**) Correlation between right external rotation ROM and cadence.

adductor, and internal and external rotators were taken by a handheld dynamometer.[6]

Gait Analysis

Gait analysis is an essential tool for assessing the biomechanics of human locomotion. In this study, we used Kinovea software to evaluate the gait of an individual by placing reflective markers on the specific anatomical areas of the lower extremities, including the greater trochanter, lateral femoral condyle, lateral malleolus, and fifth metatarsal head. Four marks were drawn on the floor, including two marks at a distance of 10 meters between them and the measurement in the video and to obtain the parameters of gait.[7]

After instrumentation, participants were asked to walk down a 10-meter-long walkway at their comfortable speed while a slow-motion video recording was made using a 240fps camera. The recording was started from the initial 2-meter and terminated at an 8-meter distance, and the reading was taken in the middle one-meter distance from the walkway. The parameters of gait, including step length, stride length, cadence, and walking speed, were analyzed using Kinovea software.[7]

Step length and stride length were obtained using the "line" tool in the software, and step length was measured by drawing a line from the heel of one foot to the heel of the other. Stride length was measured by drawing a line from the heel of one foot till the heel of the same foot touches the ground again. Cadence was measured by recording the number of steps taken in a minute while the subjects walked back and forth in their own walking speed.[7]

Walking speed was calculated by dividing the 20-meter distance covered by the time taken to complete 20 meters. By using this methodology, we were able to obtain reliable and accurate measurements of gait parameters. These parameters can be used to assess the functional limitations of individuals and develop appropriate rehabilitation programs to improve gait patterns.[7]

Table 1 Correlation of stride length with hip ROM and hip muscle strength

Correlations			
stride length (in m) with the following variables			
	Pearson correlation	*p*-Value	
Hip range of motion: right—flexion	−0.219	0.126	
Hip range of motion: right—extension	3.165	0.252	
Hip range of motion: right—abduction	0.052	0.720	
Hip range of motion: right—adduction	0.163	0.259	
Hip range of motion: right—internal rotation	0.189	0.190	
Hip range of motion: right—external rotation	0.185	0.199	
Hip range of motion: left—flexion	−0.175	0.224	
Hip range of motion: left—extension	−0.141	0.327	
Hip range of motion: left—abduction	0.225	0.116	
Hip range of motion: left—adduction	0.221	0.123	
Hip range of motion: left—internal rotation	0.265	0.046	Sig
Hip range of motion: left—external rotation	0.208	0.147	
Muscle strength: left—flexion	0.051	0.724	
Muscle strength: left—extension	0.044	0.763	
Muscle strength: left—abduction	0.090	0.535	
Muscle strength: left—adduction	0.081	0.575	
Muscle strength: left—internal rotation	0.057	0.696	
Muscle strength: left—external rotation	0.150	0.299	
Muscle strength: right—flexion	−0.009	0.953	
Muscle strength: right—extension	0.048	0.743	
Muscle strength: right—abduction	0.117	0.420	
Muscle strength: right—adduction	0.132	0.362	
Muscle strength: right—internal rotation	0.007	0.959	
Muscle strength: right—external rotation	0.020	0.891	

Abbreviation: ROM, range of motion.

Data Analysis

Statistical analysis was performed using IBM SPSS Statistics (version 26) for Windows. Descriptive statistics were utilized to analyze the demographic data, including age, gender, and occupation. The dependent variables, including step length, stride length, cadence, and walking speed, were analyzed using both descriptive statistics and correlation analysis with the independent variables of hip ROM and muscle strength.

Descriptive statistics, including minimum and maximum values, means, and standard deviations, were reported for all variables of interest. Correlations were computed using Pearson's correlation coefficient, and corresponding *p*-values were reported. A significance level of $p < 0.005$ was used to determine statistical significance.

Results

This study had 50 participants, with 29 participants in the age group of 18 to 20 years and 21 participants in age between 21 and 22 years. The occupation of all the participants were students pursuing various degree courses.

The hip joint ROM of both sides were similar at baseline in all the participants as mentioned. The muscle strength testing on left and right-side hip muscles (flexors, extensors, abductors, adductors, and rotators) showed that the muscles have similar strength on both sides. The mean stride length was 1.15 m and the step length was 0.56 m. The cadence of the participants had a mean of 120 steps/60 seconds as mentioned in ►**Table S1** (Supplementary data, available in the online version).

Pearson's correlation was used to determine the relation between various variables. A significant association between stride length left internal rotation was identified ($r = 0.265$ and $p = 0.46$; ►**Fig. 1a**/►**Table 1**). We also found a significant association between step length with left hip internal rotation ($r = 0.261$, $p < 0.001$; ►**Fig. 1b**/►**Table 2**).

There was a significant correlation between cadence and right hip external ($r = 0.259$, $p = 0.4$; ►**Fig. 1c**/►**Table 3**). We found a significant association between the walking speed

Table 2 Correlation of step length with hip ROM and hip muscle strength

Correlations			
step length (in m) with the following variables			
	Pearson correlation	*p*-Value	
Hip range of motion: right—flexion	−0.156	0.280	
Hip range of motion: right—extension	−0.155	0.282	
Hip range of motion: right—abduction	0.051	0.724	
Hip range of motion: right—adduction	0.152	0.292	
Hip range of motion: right—internal rotation	0.176	0.221	
Hip range of motion: right—external rotation	0.194	0.177	
Hip range of motion: left—flexion	−0.150	0.297	
Hip range of motion: left—extension	−0.120	0.406	
Hip range of motion: left—abduction	0.178	0.215	
Hip range of motion: left—adduction	0.194	0.177	
Hip range of motion: left—internal rotation	0.261	0.001	Sig
Hip range of motion: left—external rotation	0.216	0.132	
Muscle strength: left—flexion	0.130	0.368	
Muscle strength: left—extension	0.053	0.713	
Muscle strength: left—abduction	0.122	0.399	
Muscle strength: left—adduction	0.067	0.645	
Muscle strength: left—internal rotation	0.135	0.351	
Muscle strength: left—external rotation	0.183	0.204	
Muscle strength: right—flexion	0.082	0.573	
Muscle strength: right—extension	0.064	0.658	
Muscle strength: right—abduction	0.132	0.361	
Muscle strength: right—adduction	0.170	0.237	
Muscle strength: right—internal rotation	0.045	0.758	
Muscle strength: right—external rotation	0.074	0.611	

Abbreviation: ROM, range of motion.

Table 3 Correlation of cadence with hip ROM and hip muscle strength

Correlations			
cadence (steps/60 s) with the following variables			
	Pearson correlation (r)	$p < 0.05$	
Hip range of motion: right—flexion	0.117	0.418	
Hip range of motion: right—extension	0.009	0.949	
Hip range of motion: right—abduction	0.101	0.486	
Hip range of motion: right—adduction	0.065	0.656	
Hip range of motion: right—internal rotation	0.165	0.254	
Hip range of motion: right—external rotation	0.259	0.047	Sig
Hip range of motion: left—flexion	−0.003	0.986	
Hip range of motion: left—extension	0.073	0.615	
Hip range of motion: left—abduction	0.061	0.675	
Hip range of motion: left—adduction	0.020	0.889	
Hip range of motion: left—internal rotation	0.153	0.290	
Hip range of motion: left—external rotation	0.204	0.154	
Muscle strength: left—flexion	0.092	0.525	
Muscle strength: left—extension	−0.066	0.651	
Muscle strength: left—abduction	−0.271	0.057	
Muscle strength: left—adduction	−0.156	0.278	
Muscle strength: left—internal rotation	0.013	0.930	
Muscle strength: left—external rotation	0.026	0.858	
Muscle strength: right—flexion	−0.002	0.987	
Muscle strength: right—extension	−0.093	0.520	
Muscle strength: right—abduction	−0.077	0.596	
Muscle strength: right—adduction	−0.018	0.899	
Muscle strength: right—internal rotation	−0.185	0.199	
Muscle strength: right—external rotation	−0.137	0.344	

Abbreviation: ROM, range of motion.

and hip external rotation ROM ($r = 0.38$, $p = 0.2$; ►**Fig. 2a**/►**Table 4**). There was a significant association between walking speed and left external rotation ($r = 0.318$ and $p < 0.05$; ►**Fig. 2b**/►**Table 4**). There was a significant negative association between walking speed and muscle strength—left hip external rotation ($r = -0.604$, $p < 0.01$; ►**Fig. 2c**/►**Table 4**). Likewise, we observed a negative association between walking speed and muscle strength—right, abduction ($r = -0.314$, $p < 0.05$; ►**Fig. 2d**/►**Table 4**). We identified a negative significant association between walking speed and muscle strength—right, adduction ($r = -291$, $p < 0.05$; ►**Fig 2e**/►**Table 4**), and similar negative association was identified between muscle strength and right external rotation ($r = -0371$, $p < 0.01$; ►**Fig 2f**/►**Table 4**).

There was a positive correlation ($p < 0.05$) between left hip internal rotation ROM and stride length.

There was a positive correlation ($p < 0.05$) between left hip internal rotation ROM and step length.

There was a positive correlation ($p < 0.05$) between right hip external rotation ROM and cadence.

There was a positive correlation ($p < 0.05$) between right hip external rotation ROM and walking speed.

There was a positive correlation ($p < 0.05$) between left hip external rotation ROM and walking speed.

There was a positive correlation ($p < 0.05$) between left internal rotators muscle strength and walking speed.

There was a positive correlation ($p < 0.05$) between right abductors muscle strength and walking speed.

There was a positive correlation ($p < 0.05$) between right adductors muscle strength and walking speed.

There was a positive correlation ($p < 0.05$) between right external rotators muscle strength and walking speed.

Discussion

Gait is a fundamental parameter for assessing an individual's functional status, and it has been widely studied in various populations. The present study aimed to investigate the influence of hip ROM and strength on the spatial and temporal parameters of gait among sedentary young females.[5]

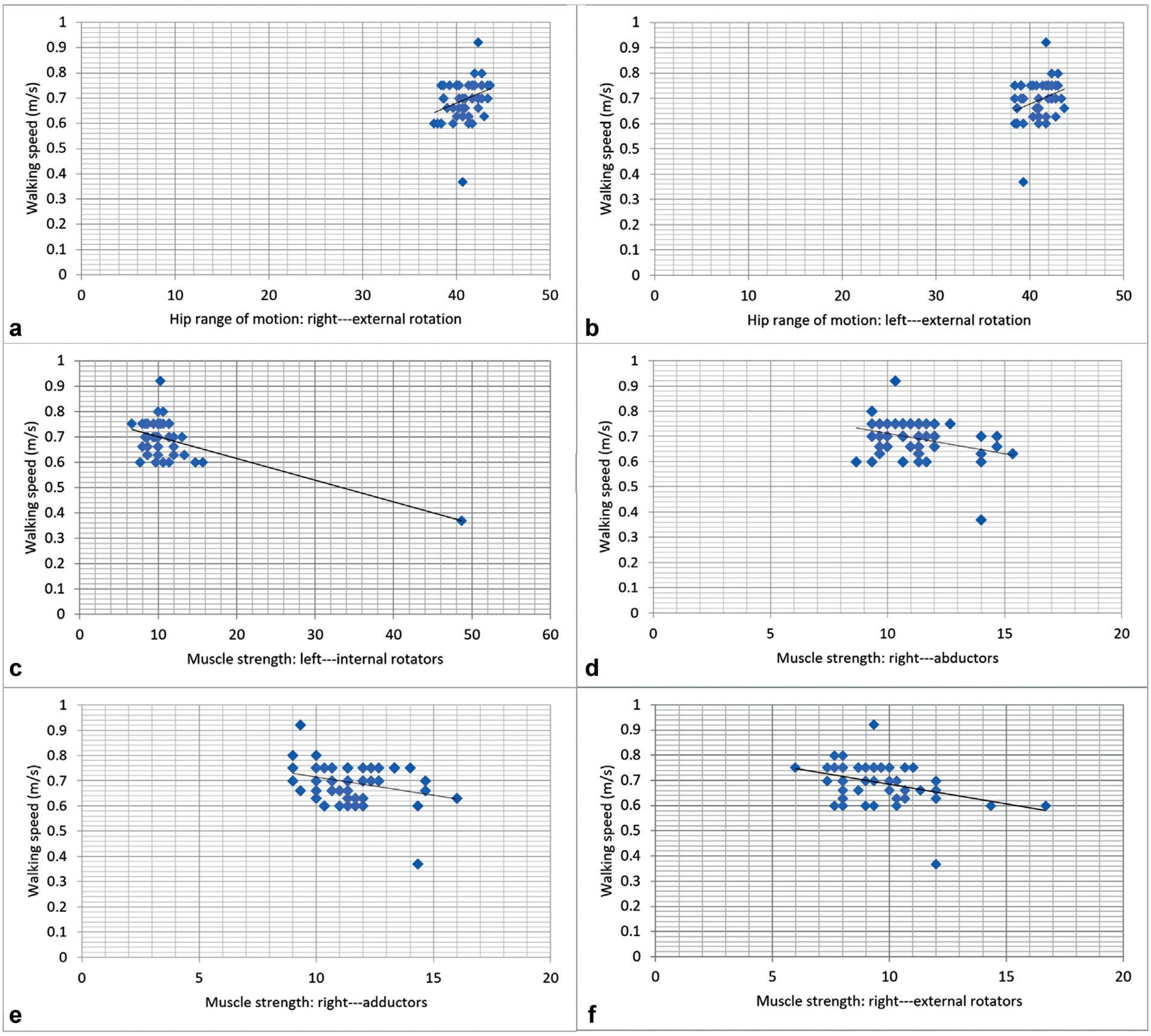

Fig. 2 (**a**) Correlation between right external rotation rom and walking speed. (**b**) Correlation between left external rotation rom and walking speed. (**c**) Correlation between left internal rotators muscle strength and walking speed. (**d**) Correlation between right abductors muscle strength and walking speed. (**e**) Correlation between right adductors muscle strength and walking speed. (**f**) Correlation between right external rotators muscle strength and walking speed.

Previous studies have reported that hip ROM and strength are crucial for the gait cycle. However, in our study, we did not find any significant correlation between the two variables, despite the younger population being sedentary. We observed that sedentary young females exhibited good muscle strength and hip mobility.[5]

Our study revealed a positive correlation between hip internal and external rotation ROM and spatial and temporal gait parameters. Females tend to have a greater hip rotation ROM than males due to their anatomically wider pelvis. We also found that during bilateral stance, the opposing gravitational moments around the right and left hips balance each other, requiring good concentric and eccentric contractions of hip adductors and abductors as well as internal and external rotators. During the single or unilateral stance phase, the adequate firing of gluteus and piriformis is crucial to maintain the equilibrium of the pelvis and trunk and prevent falls.[5]

We observed a slight reduction in hip ROM in sedentary females, but it did not affect cadence and walking speed. This may be because the ROM required for the gait cycle lies within the initial ROM of the joint, and young sedentary females exhibited good hip muscle strength and walking speed. We found that hip abductor, adductor, internal and external rotator muscle strength influenced spatial and temporal gait parameters, such as step length, stride length, cadence, and walking speed.

In conclusion, our study highlights the importance of hip ROM and muscle strength in the gait cycle among sedentary young females. It suggests that a functional position or movement that emphasizes terminal ROM should be used to assess the functional status of young populations. The findings of this study may contribute to the development of targeted interventions for improving gait and functional status in sedentary young females.

Table 4 Correlation of walking speed with hip ROM and hip muscle strength

Correlations			
walking speed (m/s) with the following variables			
	Pearson correlation (r)	$p < 0.05$	
Hip range of motion: right—flexion	0.085	0.556	
Hip range of motion: right—extension	0.027	0.850	
Hip range of motion: right—abduction	−0.098	0.500	
Hip range of motion: right—adduction	−0.014	0.925	
Hip range of motion: right—internal rotation	0.125	0.389	
Hip range of motion: right—external rotation	0.312	0.028	Sig
Hip range of motion: left—flexion	−0.079	0.584	
Hip range of motion: left—extension	−0.090	0.533	
Hip range of motion: left—abduction	−0.110	0.446	
Hip range of motion: left—adduction	−0.052	0.722	
Hip range of motion: left—internal rotation	0.162	0.260	
Hip range of motion: left—external rotation	0.318	0.024	Sig
Muscle strength: left—flexion	−0.090	0.535	
Muscle strength: left—extension	−0.028	0.845	
Muscle strength: left—abduction	−0.196	0.172	
Muscle strength: left—adduction	−0.229	0.110	
Muscle strength: left—internal rotation	−0.604	0.000	Sig
Muscle strength: left—external rotation	−0.201	0.162	
Muscle strength: right—flexion	−0.065	0.654	
Muscle strength: right—extension	−0.208	0.147	
Muscle strength: right—abduction	−0.314	0.026	Sig
Muscle strength: right—adduction	−0.291	0.040	Sig
Muscle strength: right—internal rotation	−0.202	0.159	
Muscle strength: right—external rotation	−0.371	0.008	Sig

Abbreviation: ROM, range of motion.
Note: p-Value less than 0.005 is significant.

Conclusion

The hip abductors, adductors, and internal and external rotators have shown to have influence on gait parameters especially with walking speed. The hip internal and external rotation has shown to have an influence on gait parameters. But for sedentary young females, the hip mobility is not impaired as it is a gradual process that usually gets affected as they grow older; hence, for assessing the hip mobility for young females along with gait analysis and functional measures concentrating on the end range should also be considered.

Limitations of the Study

Subjects with various grades of sedentary levels were not considered in this study. This study didn't take three-dimensional activities of daily living, particularly in lower limb examination.

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None.

Conflict of Interest

None declared.

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