ORIGINAL ARTICLE

Study of ergonomic risks to lower limb muscles in occupations involving prolonged standing and sitting

Esakkiammal. N[1], Archana Rajasundaram[2], Sudakshina Chakrabarti[1], Johnson WMS[4]*

[1]Department of Anatomy, Vels Medical College and Hospital, VISTAS, Thiruvallur-601102 (Tamil Nadu) India, [2]Department of Anatomy, Sree Balaji Medical College and Hospital, Chennai-600044 (Tamil Nadu) India, [3]Faculty of Medicine, Sri Lalithambigai Medical College and Hospital, Chennai-600095 (Tamil Nadu) India

Abstract

Background: Musculoskeletal alterations can lead to changes in posture and movement. Due to functional adaptations following postural realignments, lower extremity muscles can be overloaded, causing discomfort and pain. Biomechanical adaptations can lead to functional limitations, resulting in more stress on muscles during everyday activities. *Aim and Objectives:* This study seeked to promote ergonomic workplace strategies for healthier postures and interventions. *Material and Methods:* In this study, we recruited 554 healthy volunteers from urban settings via stratified random sampling, with one group composed of workers engaged in extended sitting time, whereas the other group consisted of individuals standing for extended periods of time. We compared lower limb muscle power values between workers engaged in prolonged standing and those in prolonged sitting using an unpaired t-test, with statistical significance set at $p < 0.05$. *Result:* Long-term standing and sitting workers exhibited statistically significant differences in lower limb muscle power. These findings indicate that stretching and strengthening exercises help to prevent overuse syndrome, musculoskeletal injuries, and alterations in muscle power associated with prolonged standing or sitting occupations. *Conclusion:* Exploratory analyses further revealed a strong association between muscle power changes and these occupational postures, highlighting the potential value of ergonomic interventions.

Keywords: Ergonomics, lower limb muscles, muscle power, manual muscle test

Introduction

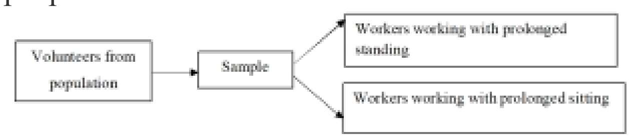
Physical fitness has become a major focus in India and globally. People are making greater efforts to enhance their physical fitness, and the sports industry is also growing. Static positions for prolonged periods of time puts excessive strain on the legs, especially on the joint [1, 2]. Maintaining fixed standing or sitting positions over time often results in stressed and taut lower limb tendons and ligaments. As a result, soreness, joint pain, and chronic musculoskeletal injuries can occur. Also, the legs' muscles can become weak and fatigued, making it difficult to walk or exercise. It is important to take breaks throughout the day to reduce the amount of time spent in the same position and to engage in light stretching or movement exercises to help maintain healthy and strong leg muscles [3, 4]. Awkward postures can lead to tendinitis, bursitis, and nerve compressions. Preventing Musculoskeletal Disorders (MSDs) requires incorporating regular work breaks, conducting ergonomic evaluations, implementing job rotation and task modifications, and ensuring the use of appropriate tools and equipment. Employees should also receive training on correct body mechanics and early recognition of MSD symptoms. These disorders arise from multifaceted causes, encompassing individual, biomechanical, and psychosocial elements. While initial job assessments often target workplace design or administrative practices that contribute to MSDs, broader evaluations are essential, recognizing workers as individuals with distinct beliefs and attitudes toward their roles. Such personal perspectives on work demands have been linked to on-the-job musculoskeletal discomfort and can affect workers' willingness to adopt workplace improvement recommendations [5]. Understanding static versus dynamic postures is crucial for workers to adopt job-specific ergonomics. Static postures (standing, sitting, crouching) remain fixed, appearing comfortable for prolonged periods but risking fatigue. Dynamic postures (bending, reaching) involve movement, reducing muscular strain and enhancing circulation. Balancing both prevents health issues, as excessive static loading impairs blood flow while dynamic activity promotes recovery. Workers maintaining this equilibrium ensure ergonomic health and productivity [6-8].

Posture is an important indicator of overall health and wellbeing, as it can give insight into physical, mental, and emotional states. Muscle activity causes increase in intramuscular tension and length changes in muscles. During muscle activity, muscle fibers are contracted and relaxed. According to the difference in the length and tone of the muscles, these muscle works can be categorized into isotonic contractions and isometric contractions. In deter-mining muscle power, work-related activities exert considerable influence. Muscle and soft tissue undergo changes due to continuous maintenance of one posture, which may modify walking patterns. Due to their occupation, the person may adopt specific postures or develop different gait patterns, which may affect their normal gait patterns. To increase stability on a ship, sailors require a wider base, which leads to adjusting their posture, the abductor of hip may tighten, and the adductor of hip may be stretched and wasted. According to Lakshmi Narayanan (2005), changes in muscular attributes require adopting a new walking pattern for regular tasks [9]. Gait awareness aids occupational health by integrating body structures for postural stability, countering internal/external forces in standing/sitting. This study assesses gait variability's link to lower limb muscle power amid control deficits. Posture alters lower limb loading during work, necessitating interventions against MSDs. Prior literature overlooks lower limb ergonomics in mixed standing /sitting jobs, focusing broadly on MSDs. Our work fills this gap, providing data to guide ergonomic strategies and healthier practices [10-13]. The existing literature lacks comprehensive understanding of the ergonomic effects on the lower limbs among employees who are involved in both standing and sitting activities. Previous studies have mainly focused on general aspects of MSDs rather than specific regional impacts, such as those related to the lower limbs. Recognizing these lacunae, the present study was conducted to provide valuable data and insights pertaining to lower limb health in the realm of occupational health. Furthermore, our research aimed to raise awareness about improved workplace practices, to guide workplace interventions, and to facilitate the formation of ergonomic strategies that should promote healthier work habits.

Material and Methods

A cross-sectional study was designed to evaluate the extent of ergonomic effects in lower extremity muscle strength. In addition, the study assessed the impact of standing and sitting for long duration on muscle power variability. This study received

Institutional Ethics Committee approval (Ref. No. 002/ SBMC/IHEC/2019/1221) and was conducted at Sree Balaji Medical College, Chennai, India. Total of 554 subjects were chosen from the Chennai population through the random sampling method via direct interaction with participants at their workplace and who volunteered to take part in the research. Sample populations were drawn from the participants of workers in two groups from different sectors in Chennai. One group of workers was allotted from prolonged sitting positions, including drivers, IT professionals, and bank staff of both genders. A second group comprised male and female prolonged-standing workers, including traffic officers, builders, and shop/textile sales people.



Eligible study participants were healthy individuals aged 20–60 years who had provided informed consent, possessed at least one year of work experience in their respective occupations, worked in jobs requiring extended standing and sitting for at least eight hours per day, and had no pre-existing lower limb musculoskeletal conditions or injuries. Individuals with known chronic musculoskeletal disorders, a history of lower limb surgeries, fractures, or injuries within the past year and pregnant women were excluded from the study. Additionally, employees with prior cardiovascular or neurological conditions or substance abuse or any clinical condition that impact their participation or data reliability and participants unwilling to comply with study procedures or provide accurate information were excluded.

Manual muscle testing

Muscle testing forms an essential component of the physical examination. It provides information not obtained by other procedures, useful in the differential diagnosis, prognosis and treatment of neuromuscular and musculoskeletal disorders. Musculoskeletal conditions often exhibit characteristic patterns of muscle imbalance. Few patterns are related with handedness, some with habitually poor posture. Muscle imbalance occurs due to occupational or recreational activities in which there is the persistent use of certain muscles without the adequate exercise of opposing muscles. The imbalance that affects body alignment is an essential factor in many painful postural conditions. Muscle imbalance distorts alignment and sets the stage for undue stress and strain on joints, ligaments, and muscles. Manual muscle testing is the tool of choice to determine the extent of imbalance. The muscle strength is graded on a scale. We used the Medical Research Council (MRC) proposed standard manual muscle testing scale in the study [14]. Key lower limb muscles were tested manually against resistance, and strength was rated using a standard 0-5 grading system.

0 - No activity of muscle

1 – Trace muscle activation, such as flickering, without achieving a full range of motion.

2 – Muscle movement with elimination of gravity, achieving complete joint range of motion

3 – Movement of muscle against gravity, complete joint range of motion

4 - Movement of muscle against moderate resistance, complete joint range of motion

5 - Movement of muscle against examiners maximum resistance, complete joint range of motion

Statistical analyses were performed using unpaired t-test, Chi-square test, and Pearson's correlation test. A value of $p < 0.05$ was considered statistically significant. Data were entered into Microsoft Excel (version 2021) and analyzed accordingly.

Results

The prevalence of muscle power alterations in the study population was computed as percentages. In this study, prolonged standing and sitting workers demonstrated statistically significant differences in lower limb muscle power.

Measurements of muscle power

In rehabilitation step-ups, muscle strength testing has long been an important assessment procedure. Manual Muscle Testing (MMT) is a simple method, yet an effective way to evaluate the strength of muscles in a person's body. It is a non-invasive technique that involves applying resistance to a muscle while the person contracts that muscle. The aim of manual muscle testing is to identify weaknesses or deficiencies in a person's muscular system and to monitor their progress during rehabilitation. A MMT graded from 0 to 5 according to the MRC scale was performed on muscles acting on the joints of lower extremity (hip, knee, ankle) of healthy subjects as shown in Tables1 and 2 and Figures 1 and 2.

Table 1: Association of muscle power of hip joint in long-term standing and sitting workers

Hip-joint Muscle power			Grade			Chi-square	*p*
			Grade 3	Grade 4	Grade 5		
Hip flexors	**Standing**	**Observed Count**	19	166	92	112.144	<0.001
		Expected Count	17.0	107.5	152.5		
		Percentage	6.9%	59.9%	33.2%		
	Sitting	**Observed Count**	15	49	213		
		Expected Count	17.0	107.5	152.5		
		Percentage	5.4%	17.7%	76.9%		
Hip extensors	**Standing**	**Observed Count**	15	91	171	25.569	<0.001
		Expected Count	12.5	120.5	144.0		
		Percentage	5.4%	32.9%	61.7%		
	Sitting	**Observed Count**	10	150	117		
		Expected Count	12.5	120.5	144.0		
		Percentage	3.6%	54.2%	42.2%		

Continued...

Hip abductors	**Standing**	**Observed Count**	44	166	67	173.524	<0.001
		Expected Count	25.0	108.0	144.0		
		Percentage	15.9%	59.9%	24.2%		
	Sitting	**Observed Count**	6	50	221		
		Expected Count	25.0	108.0	144.0		
		Percentage	2.2%	18.1%	79.8%		
Hip Adductors	**Standing**	**Observed Count**	8	83	186	38.608	<0.001
		Expected Count	21.5	102.5	153.0		
		Percentage	2.9%	30.0%	67.1%		
	Sitting	**Observed Count**	35	122	120		
		Expected Count	21.5	102.5	153.0		
		Percentage	12.6%	44.0%	43.3%		
Hip medial rotators	**Standing**	**Observed Count**	9	80	188	54.637	<0.001
		Expected Count	27.5	101.0	148.5		
		Percentage	3.2%	28.9%	67.9%		
	Sitting	**Observed Count**	46	122	109		
		Expected Count	27.5	101.0	148.5		
		Percentage	16.6%	44.0%	39.4%		
Hip lateral rotators	**Standing**	**Observed Count**	84	130	63	164.689	<0.001
		Expected Count	47.5	93.0	136.5		
		Percentage	30.3%	46.9%	22.7%		
	Sitting	**Observed Count**	11	56	210		
		Expected Count	47.5	93.0	136.5		
		Percentage	4.0%	20.2%	75.8%		

Table 2: Association of muscle power of knee and ankle joints in long-term standing and sitting workers

Knee/Ankle-Joint Muscle power			Grade			Chi-square	*p*
			Grade 3	Grade 4	Grade 5		
Knee-joint Flexors	**Standing**	**Observed Count**	34	133	110	67.589	<0.001
		Expected Count	21.0	99.0	157.0		
		Percentage	12.3%	48.0%	39.7%		
	Sitting	**Observed Count**	8	65	204		
		Expected Count	21.0	99.0	157.0		
		Percentage	2.9%	23.5%	73.6%		
Knee-joint Extensors	**Standing**	**Observed Count**	6	71	200	46.316	<0.001
		Expected Count	13.0	103.0	161.0		
		Percentage	2.2%	25.6%	72.2%		
	Sitting	**Observed Count**	20	135	122		
		Expected Count	13.0	103.0	161.0		
		Percentage	7.2%	48.7%	44.0%		
Ankle-joint Plantarflexors	**Standing**	**Observed Count**	5	128	144	64.602	<0.001
		Expected Count	4.0	85.0	188.0		
		Percentage	1.8%	46.2%	52.0%		
	Sitting	**Observed Count**	3	42	232		
		Expected Count	4.0	85.0	188.0		
		Percentage	1.1%	15.2%	83.8%		
Ankle-joint Dorsiflexors	**Standing**	**Observed Count**	24	175	78	34.892	<0.001
		Expected Count	12.0	165.0	100.0		
		Percentage	8.7%	63.2%	28.2%		
	Sitting	**Observed Count**	0	155	122		
		Expected Count	12.0	165.0	100.0		
		Percentage	0.0%	56.0%	44.0%		

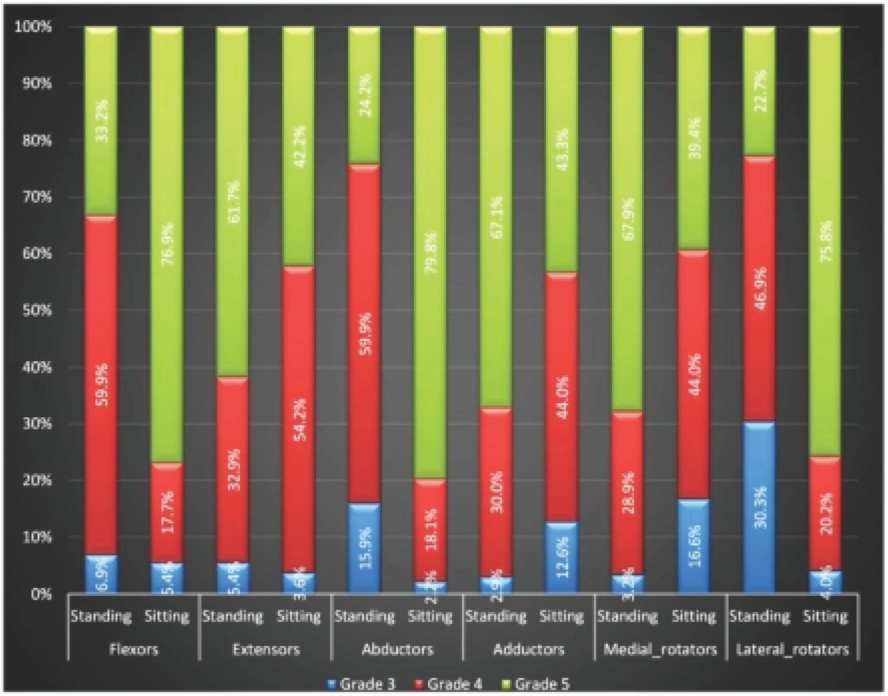


Figure 1: Comparison of hip-joint muscle power between prolonged standing and sitting workers

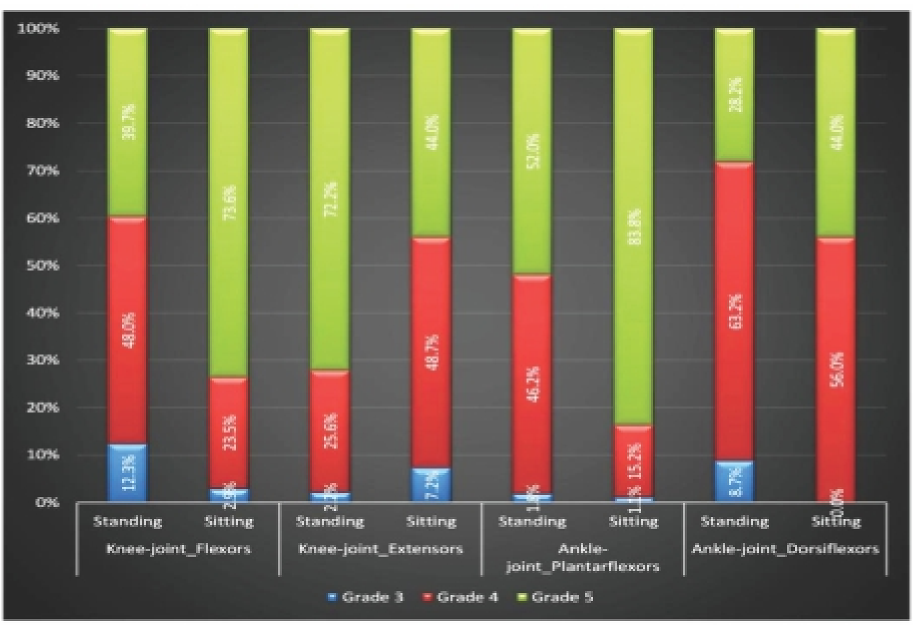


Figure 2: Comparison of knee and ankle joint muscle power between long-term standing and sitting workers

Association of muscle power in long-term standing and sitting workers

In the standing position, we found a significant association between hip flexor muscle power and work position (chi-square = 112.144, $p < 0.001$) (Table 1). Specifically, Grade 4 and Grade 5 muscle power were more prevalent in standing workers compared to Grade 3. In the sitting position, there was also a significant association (chi-square = 76.9, $p < 0.001$), with Grade 5 muscle power being highly prevalent among sitting workers. Similar to hip flexors, there was a notable correlation between hip extensor muscle power and work position in both standing (chi-square = 25.569, $p < 0.001$) and sitting (chi-square = 42.2, $p < 0.001$) positions. Grade 5 muscle power was more prevalent in both positions. The data revealed a notable correlation between hip abductor muscle power and work position in both standing (chi-square = 173.524, $p < 0.001$) and sitting (chi-square = 79.8, $p < 0.001$) positions. Grade 5 muscle power was highly prevalent among sitting workers, while in the standing position, Grade 4 muscle power was also notable. There was a notable correlation between hip adductor muscle power and work position in both standing (chi-square = 38.608, $p < 0.001$) and sitting (chi-square = 43.3, $p < 0.001$) positions. Grade 5 muscle power was more prevalent in both positions. Similarly, the data revealed a notable correlation between hip medial rotator muscle power and work position in both standing (chi-square = 54.637, $p < 0.001$) and sitting (chi-square = 39.4, $p < 0.001$) positions. Grade 5 muscle power was highly prevalent among sitting workers, while in the standing position, Grade 4 muscle power was also notable. There was a notable correlation between power of muscles responsible for hip lateral rotation and work position in both standing (chi-square = 164.689, $p < 0.001$) and sitting (chi-square = 75.8, $p < 0.001$) positions as shown in Figure 1. Grade 4 muscle power was more prevalent in both positions. These findings indicate the importance of considering hip muscle power in understanding the physical demands and adaptations associated with different work positions that could influence occupational health and ergonomics

MMT of lower limb muscles in workers with long -term standing and sitting: correlation with age

In both standing and sitting positions, there was a negative correlation between age and the strength of hip flexor muscles. This indicates that as individual's age, their hip flexor muscle strength tends to decrease. These associations exhibit statistical significance. Similar to hip flexors, there was a marked negative correlation between age and hip extensor muscle strength in both standing and sitting positions. Older individuals tend to have weaker hip extensor muscles. These associations exhibit statistical significance ($p < 0.001$). There was a marked inverse relation between age and hip abductor muscle strength in both standing and sitting positions. This suggests that with advancing age, their capacity to abduct the hip joint (move the leg away from the body) decreased significantly. These associations were highly statistically significant ($p < 0.001$). In both standing and sitting, there was a significant negative relationship between age and hip adductor muscle strength. As individuals age, their hip adductor muscles tend to become weaker. These associations were statistically significant ($p < 0.001$). Both the medial and lateral rotator muscles of the hip showed a marked negative correlation with age in both standing and sitting positions. Older individuals tend to have weaker hip rotator muscles. These associations exhibited statistical significance ($p < 0.001$).

In both standing and sitting, there was a marked negative correlation between age and the strength of knee-joint flexor and extensor muscles. Older individuals tend to have weaker knee muscles. These associations exhibit statistical significance ($p < 0.001$). In both standing and sitting, there was a significant negative correlation between age and the strength of ankle-joint plantar flexor and dorsiflexor muscles. As individuals age, their ankle muscle strength tends to decrease. These associations exhibit statistical significance ($p < 0.001$) as shown in Table 3. These findings highlight the importance of considering age-related changes in muscle strength when assessing the health and functional capacity of workers in jobs that require prolonged standing and sitting.

A correlation relation between weight and muscle power in prolonged standing and sitting workers

In the standing position, there was a marked inverse relationship between weight and hip flexor muscle power, meaning that individuals with a higher weight tend to have weaker hip flexor muscles. In the sitting position, there was no significant correlation between weight and hip flexor muscle power. In both standing and sitting positions, there was a marked inverse relationship between weight and hip extensor muscle power. This indicated that individuals with elevated body weight tend to have weaker hip extensor muscles in both occupational positions. In the standing position, there was a marked inverse relationship between weight and hip abductor muscle power, suggesting that obese individuals tend to have weaker hip abductor muscles. In the sitting position, there was no correlation between weight and hip abductor muscle power. In both standing and sitting positions, there

Table 3: Correlation between age and MMT of lower limb muscles in workers prolonged standing and sitting

Muscles	Standing		Sitting	
	Correlation	*p*	Correlation	*p*
Hip Flexors	0.541	<0.001	0.365	<0.001
Hip Extensors	0.381	<0.001	0.399	<0.001
Hip Abductors	0.670	<0.001	0.246	<0.001
Hip Adductors	0.304	<0.001	0.501	<0.001
Hip Medial rotators	0.383	<0.001	0.400	<0.001
Hip Lateral rotators	0.620	<0.001	0.399	<0.001
Knee Flexors	0.338	<0.001	0.393	<0.001
Knee Extensors	0.341	<0.001	0.454	<0.001
Ankle Plantarflexors	0.477	<0.001	0.431	<0.001
Ankle Dorsiflexors	0.557	<0.001	0.425	<0.001

was a significant negative correlation between weight and hip adductor muscle power. This indicated that individuals with elevated body weight tend to have weaker hip adductor muscles in both occupational positions. Similar to hip adductors, there was a significant negative correlation between weight and hip medial rotator muscle power in both standing and sitting positions. In the standing position, there was a significant negative correlation between weight and hip lateral rotator muscle power, suggesting that obese individuals tend to have weaker hip lateral rotator muscles.

In the sitting position, there was a significant positive correlation, indicating that individuals with elevated body weight tend to have stronger hip lateral rotator muscles when sitting. In both standing and sitting positions, there was no significant correlation between weight and knee-joint flexor and extensor muscle power. This suggested that weight does not strongly influence the strength of these muscle groups in either position. In the standing position, there was a marked negative correlation between weight and ankle-joint plantar flexor muscle power, suggesting that obese individuals tend to have weaker ankle plantar flexor muscles. In the sitting position, there was a positive correlation, indicating that individuals with elevated body weight tend to have stronger ankle plantar flexor muscles when sitting. Weight was also negatively correlated with ankle-joint dorsiflexor muscle power in the standing position (Table 4). These findings highlight the significance of considering weight as a variable when assessing lower limb muscle power in workers who engage in prolonged standing and sitting, as it may have implications for their physical capabilities and occupational health.

Table 4: Relationship between weight and MMT among long-term standing and sitting workers

Muscles	**Standing**		**Sitting**	
	Correlation	***p***	**Correlation**	***p***
Hip Flexors	0.194	0.001	0.069	0.255
Hip Extensors	0.317	<0.001	0.090	0.133
Hip Abductors	0.251	<0.001	0.041	0.500
Hip Adductors	0.344	<0.001	0.022	0.721
Hip Medial rotators	0.319	<0.001	0.096	0.113
Hip Lateral rotators	0.265	<0.001	0.203	0.001
Knee Flexors	0.093	0.121	0.005	0.940
Knee Extensors	0.024	0.689	0.205	0.001
Ankle Plantar flexors	0.514	<0.001	0.218	<0.001
Ankle Dorsiflexors	0.402	<0.001	0.103	0.089

In prolonged standing and sitting workers, lower limb muscle power correlated with time spent at work

In the standing position, there was a strong direct association between the amount of time spent working and hip flexor muscle power. This indicated that individuals who spend more time at work standing tend to have stronger hip flexor muscles. In the sitting position, a similar positive correlation was observed, indicating that more work hours spent sitting were associated with stronger hip flexors. In the standing position, there was a strong direct association between work duration and hip extensor muscle power, meaning that individuals who spend more time standing at work tend to have stronger hip extensors. However, in the sitting position, there was no significant correlation between work duration and hip extensor muscle power. Both in standing and sitting positions, there was a strong direct association between work duration and hip abductor muscle power. This suggested that spending more time at work was associated with a stronger hip abductor. In both standing and sitting positions, there was a strong direct association between work duration and hip adductor muscle power. This indicated that individuals who spend more time at work tend to have stronger hip adductors. There was a strong direct association between work duration and hip medial rotator muscle power in both standing and sitting positions. This suggested that more work hours were associated with stronger hip medial rotators. In both standing and sitting positions, there was a strong direct association between work duration and power of muscles responsible for hip lateral rotation. This indicated that individuals who spend more time at work tend to have stronger hip lateral rotators.

In both standing and sitting positions, there was a strong direct association between work duration and knee-joint flexor muscle power. This indicated that increased work hours were associated with stronger knee-joint flexors. In the sitting position, there was a strong direct association between work duration and knee-joint extensor muscle power, indicating that more work hours spent sitting were associated with stronger knee-joint extensors. In both standing and sitting positions, there was a strong direct association between work duration and ankle-joint plantar flexor muscle power. This suggested that more work hours were associated with stronger ankle-joint plantar flexors. In the standing position, there was a significant positive correlation between work duration and ankle-joint dorsiflexor muscle power, suggesting that more duration spent standing at work was associated with stronger ankle dorsiflexors. However, in the sitting position, there was no correlation between work duration and ankle dorsiflexor muscle power (Table 5).

Table 5: Correlation of working hours and MMT in long-term standing and sitting workers

Muscles	Standing		Sitting	
	Correlation	*p*	Correlation	*p*
Hip Flexors	0.121	0.045	0.174	0.004
Hip Extensors	0.187	0.002	0.018	0.770

Continued...

Hip Abductors	0.190	0.002	0.328	<0.001
Hip Adductors	0.204	0.001	0.128	0.033
Hip Medial rotators	0.322	<0.001	0.268	<0.001
Hip Lateral rotators	0.219	<0.001	0.152	0.011
Knee Flexors	0.111	0.066	0.206	0.001
Knee Extensors	0.133	0.027	0.215	<0.001
Ankle Plantar flexors	0.107	0.076	0.303	<0.001
Ankle Dorsiflexors	0.129	0.031	0.034	0.568

In summary, the study results indicate that generally positive correlation between duration of occupational activity and muscle power of lower extremity muscle groups in workers who engage in prolonged standing and sitting. This suggests that long work durations were correlated with enhanced lower limb muscles strength, which was due to the physical demands of these occupations.

Long-term standing and sitting employees' MMT of lower limb muscles was correlated with their years of work experience

In both standing and sitting positions, there was a marked inverse relationship between the number of years of experience in specific work and the muscle power of hip the flexor muscles. This indicated that as employees accumulated more years of work experience, their hip flexor muscle power tend to decrease. These correlations exhibited high statistical significance (*p* < 0.001). Similarly, there was a marked inverse relationship between work experience and hip extensor muscle power in both standing and sitting positions. This suggests that as employees gained more years of work experience, their hip extensor muscles tend to become weaker. These correlations exhibited high statistical significance (*p* < 0.001). In both standing and sitting positions, there was a marked inverse relationship between work experience and hip abductor muscle power. As employees accumulated more work experience, their hip abductor muscles tend to weaken. These correlations exhibited high statistical significance (*p* < 0.001).

There was an inverse relationship between work experience and hip adductor muscle power in both standing and sitting positions. This indicated that as employees gained more years of work experience, their hip adductor muscles tend to become weaker. These correlations exhibited high statistical significance (*p* < 0.001). In both standing and sitting positions, there was a marked inverse relationship between work experience and the muscle power of hip medial rotators and lateral rotators. As employees accumulated more years of work experience, their hip rotator muscles tend to weaken. These correlations exhibited high statistical significance (*p* < 0.001). In both standing and sitting positions, there was a marked inverse relationship between work experience and the muscle power of knee joint flexors and extensors. This suggested that as employees gained more years of work experience, their knee muscles tend to become weaker. These correlations exhibited high statistical significance (*p* < 0.001). In both standing and sitting positions, there was a marked inverse relationship between

Table 6: The relation between work experience and MMT for long-term standing and sitting workers.

Muscles	Standing		Sitting	
	Correlation	*p*	Correlation	*p*
Hip Flexors	0.537	<0.001	0.444	<0.001
Hip Extensors	0.361	<0.001	0.638	<0.001
Hip Abductors	0.605	<0.001	0.406	<0.001
Hip Adductors	0.295	<0.001	0.743	<0.001
Hip Medial rotators	0.327	<0.001	0.694	<0.001
Hip Lateral rotators	0.574	<0.001	0.517	<0.001
Knee Flexors	0.391	<0.001	0.617	<0.001
Knee Extensors	0.286	<0.001	0.716	<0.001
Ankle Plantar flexors	0.397	<0.001	0.556	<0.001
Ankle Dorsiflexors	0.503	<0.001	0.707	<0.001

work experience and the muscle power of ankle joint plantar flexors and dorsiflexors. As employees accumulated more years of work experience, their ankle muscles tend to weaken. These correlations exhibited high statistical significance ($p < 0.001$) as shown in Table 6. These results emphasize the necessity of considering the effect of long-term work experience on lower limb muscle strength in individuals with extended exposure to standing and sitting positions.

Discussion

The proposed method enables physicians to evaluate medical conditions based on muscle strength using MMT. For strength conditioning programs and rehabilitative procedures, MMT is sufficient for quantifying muscle strength. Lower socio-economic status people could benefit from MMT. By delving into this topic, we can enhance workplace conditions and mitigate the negative consequences of prolonged sitting and standing.

Our findings on elevated hip muscle power (Grade 4-5) in both standing and sitting workers align with Reid and Fielding (2012) [15], who established skeletal muscle power as a critical determinant of physical functioning, declining faster than strength with age and strongly predicting mobility. Higher power supports postural demands in occupational settings, mirroring their evidence that leg extensor power better explains functional tasks like stair climbing and gait than strength alone.

These results also resonate with demonstration of Messier *et al*. (2005) [16] that weight loss proportionally reduces knee-joint loads, implying sustained muscle power in our cohorts mitigates hip/knee strain from prolonged postures. Unlike their OA-focused older adults, our working population showed preserved power, potentially buffering ergonomic risks; however, contradictions may arise in aging workers, as power deficits precede overt disability. Future studies should explore interventions enhancing hip power for occupational health.

Our data also showed consistent negative correlations between age and strength across all lower limb movements in standing/sitting workers. These age-related declines mirror Neumann's (2016) [17] kinesiology framework, linking sarcopenia to reduced lower limb torque production and impaired gait/posture stability. Supporting evidence from this study showed quadriceps weakness emerging by middle age, marked hip abductor/adductor losses (34-56%), and ankle plantar flexor deficits. No major contradictions noted, emphasizing targeted training for occupational health. We also found strong negative correlations between years of work experience and muscle power across all lower limb movements in both standing and sitting workers ($p < 0.001$). These findings indicated cumulative occupational strain eroded lower limb strength over time. Consistent with Robbins and Waked (1997) [18], who linked prolonged vertical loading to balance deficits and muscle fatigue, our results extend this to hip/knee/ ankle power declines in static postures. Supporting Buckwalter and Martin (2006) [19] on osteoarthritis progression from repetitive stress, no contradictions noted; interventions targeting veteran workers are urged.

According to the results of the study, the mean age and weight of long-term standing workers were statistically significant. These results align with other studies demonstrating the positive impact of standing workstations on reducing sitting time and maintaining a healthy weight [20, 21]. The study also revealed that work experiences were significantly different for prolonged standing and sitting workers. Another research on the relationship between running and mental health found that exercise had a positive impact on mental health and well-being [22].

Using ergonomic principles by adjusting workstations, promoting proper posture, and providing ergonomic tools reduces these risks. Investing in ergonomic interventions not only safeguards employee health but also enhances productivity, demonstrating the imperative role of ergonomics in preventing occupational-related injuries. Prolonged standing and sitting both have negative impacts on musculoskeletal health. While prolonged standing can cause strain over lower back region and pain in the leg, prolonged sitting can lead to hip joint stiffness and reduced range of motion [23-24]. According to Serbest *et al*. (2015) [25], prolonged standing and sitting were related with negative effect on health. The study's findings indicated that promoting physical activity and reducing sedentary behavior in the workplace was vital for maintaining musculoskeletal health.

The study found that prolonged standing workers had significantly reduced lower limb joint range of motion in the knee and ankle, while prolonged sitting workers had higher muscle power in the knee and ankle. This aligns with prior research documenting adverse musculoskeletal effects of prolonged standing, including heightened risks of varicose veins, low back pain, and foot disorders [26, 27]. However, the research also found that prolonged sitting had negative health outcomes, such as obesity and cardiovascular condition [25]. In conclusion, our findings on posture-related hip muscle power, age/work experience declines, and occupational strain emphasizing lower limb adaptations. Prasetiowati *et* *al*. (2017) [28] and Guzmán-Muñoz *et al*. (2023) [29] respectively linked body mass index and physical activities to impaired balance and relative hip/knee extensor weakness in upright postures, while the study by Mohan *et al*. (2017) [30] confirmed obesity-driven peripheral strength alterations relevant to prolonged standing/ sitting. These corroborate ergonomic needs, advocating targeted training for workers. Future interventions can mitigate risks, enhancing occupational health. The strengths of this study are that it provides insights into the impact of prolonged standing and sitting on lower-limb health. Thus, occupational health initiatives become essential interventions to promote physical activity and reduce prolonged sedentary behavior at work, and that the ergonomic needs of standing and sitting workers are also addressed. The study used MMT grades, which could be a reliable instrument for objectively evaluating muscle strength in rehabilitation settings.

However, the study has limitations too. First, the study was cross-sectional, which means limiting the generalizability of these findings to other populations or contexts. Moreover, the study did not account for potential confounders like age, gender, and physical activity levels, which could have affected the outcomes. Finally, the study relied on self-reported data, which may be subject to bias and inaccuracies. Although the study has some limitations, the results suggest that occupational health interventions should focus on promoting physical activity, reducing long lasting sedentary behavior, and addressing workers' ergonomic needs. People who maintain the same posture for a long time, like workers in the fields of construction, carrying heavy loads, automotive, agriculture and the army are highly exposed to fatigue and work-related injuries. This study reconsiders the occupational hazard as a threat to the alteration of lower limb muscle power which can be approached for prevention.

The study's future scope includes conducting prospective studies accounting for confounding variables, using objective measures of physical activity, and exploring the effectiveness of workplace interventions. These interventions could include ergonomic adjustments to workstations, promoting physical activity during work breaks, and encouraging employees to engage in regular exercise. Moreover, the study's findings may inform policy decisions intended to reduce sedentary behavior in the workplace and promote musculoskeletal health. Furthermore students, researchers, and investigators in different disciplines can integrate the understanding of occupational-related movement changes. Therefore, we should sensitize workers across multiple worksites about the effect of alterations in lower limb muscle power in the workplace and the risks associated with various occupations.

Conclusion

This study reveals significant decline in lower limb muscle power among workers maintaining prolonged standing or sitting postures, with notable associations between work position and hip muscle strength grades. Age and occupational tenure further exacerbate these deficits across hip flexors, extensors, abductors, adductors, rotators, knee flexors/ extensors, and ankle plantar/dorsiflexors. These findings underscore ergonomic hazards in static occupational settings, linking muscle imbalances to heightened musculoskeletal disorder risk. Targeted interventions —such as workstation modifications, periodic movement breaks, and strength training— are essential to preserve muscle function, improve postural stability, and safeguard worker health and productivity.

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***Author for Correspondence:**
Dr. Esakkiammal. N, Department of Anatomy, Vels Medical College and Hospital, Tiruvallur – 601102 Email. esakkiammaln6@gmail.com Cell: 9650525642

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