

Exploratory Data-Driven Insights on Lower Limb Health of Female Teaching Professionals: A Survey

Kavitha Rajamohan* and Jethro Jarvis Roy Jyrwa*

Abstract

Gait or walking is a fundamental activity that has an influence over our health. Variations in gait or walking patterns among female teaching professionals are prevalent. This survey discusses the data-driven analysis related to work habits, physical health, and lower limb health. The main aim of this study is to see how these factors affect the overall gait health of the individual. A survey was conducted on 46 female teaching professionals in higher education where they responded to the questions on their ergonomic, health, and lower limb conditions. A data-driven analysis was conducted on the data to answer the research questions. The data-driven analysis reveals that long hours of standing at work, type of shoes worn, and the presence of symptoms in the lower limbs increase the pain and discomfort felt by female teaching professionals. Interventions in ergonomic conditions and sensitisation through health education are needed to curb the presence of such conditions, which lead to musculoskeletal disorders. This study helps to understand that small changes in lifestyle may improve gait and how the regular physical activities can be corrected if required.

Keywords: Gait, Gait Analysis, Data-driven analysis, female teaching professionals, educators, health, ergonomics

1. Introduction

Walking is a fundamental or basic human activity that influences over-all

* Department of Computer Science, CHRIST (Deemed to be University), Bangalore, Karnataka, India; kavitha.r@christuniversity.in; jethrojyrwaroy@gmail.com

health. The term gait refers to an individual’s walking pattern or style, which can be influenced by factors like balance, posture, and coordination. Walking patterns or gait is a health indicator as a person’s signature gait or the unique sequential walking pattern in humans can reveal key information about certain underlying health issues. In connection with this, any changes in gait patterns may show complications in musculoskeletal, neurological, or occupation-related health concerns [1]. These changes in gait can lead to discomfort, reduced mobility with an increased risk of falls, particularly among professionals who spend more hours standing or putting stress on their feet. In Figure 1 we see the normal gait pattern among humans as an illustration.

Teaching professionals in academic institutions experience long hours of standing and walking as part of their daily routine. In this regard, many teaching professionals experience musculoskeletal disorders due to such ergonomic conditions. This study aims to analyze the changes in the walking patterns among female teaching professionals and identify the changes in gait through a structured questionnaire. By examining the duration of standing and sitting, movement patterns, footwear choices, overall general health, lower limb health, and exercise habits, this study provides meaningful insights into the relationship between occupational demands and gait changes. These insights can help to develop suggestions for better workplace ergonomics, risk-reducing healthcare strategies, and interventions to improve mobility among the teaching professionals.

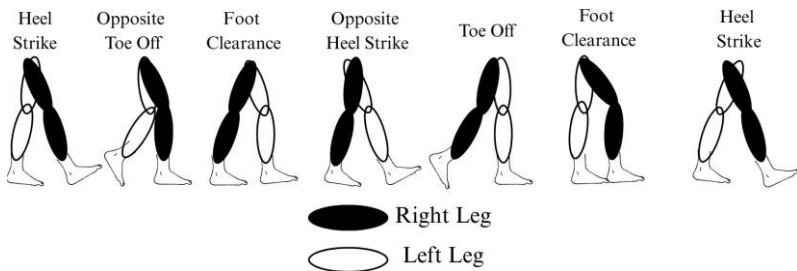


Figure 1: Gait Pattern among Humans

2. Literature Review

A review of the literature has been conducted to understand the current state of knowledge with regards to musculoskeletal disorders and gait patterns among female teaching professionals which has been divided into two sections to understand the literature on Teaching Professionals, Walking Behaviour, and Health, and the Data Driven Analysis and Clinical Analysis.

2.1 Teaching Professionals, Walking Behaviour, and Health

A review conducted by Ayuni Nabilah Alias et al. [2] establishes that teaching professionals who stand for prolonged hours are often associated with musculoskeletal disorders. Prolonged standing among teaching professionals may lead to body pain, discomfort, muscle fatigue, and musculoskeletal disorders which is mainly caused by the deterioration of posture. The development of these musculoskeletal disorders among teaching professionals likely results in altered gait patterns. A systematic review of literature regarding the musculoskeletal disorders among teaching professionals conducted by Somayeh Tahernejad et al. [3] establishes that teachers face numerous ergonomic risk factors such as awkward postures and prolonged standing. The study finds that overall prevalence of musculoskeletal disorders is substantially high at 68%, with the most commonly affected areas being the neck and lower back.

2.2 Data-Driven Analysis and Clinical Analysis

A data-driven analysis provides evidence-based findings that enable analysis and the answering of research questions using survey data. This analysis is precise, contextualised, and objective, such that data quality is also improved to provide a sophisticated data-driven analysis [4]. Along with data driven analysis, clinical analysis with respect to gait wherein patients' data are taken into account to come to various conclusions for underlying conditions that patients may have due to altered gait patterns such as in the study conducted by Halimatul Abd Ghani et al. [5] where they clinically analyse the lower limb muscles and how they affect gait parameters. Another study conducted by Daniela Ciprandi et al. [6] concluded that within a population of healthy elderly women, those who were more physically active had less variability in their gait (i.e., their walking was steadier and more consistent). Conversely, those who were less active showed greater gait variability (i.e., their walking was more uneven). This signifies that physical activity is associated with gait analysis.

On reviewing the literature, our data-driven analysis aims to answer the following research questions among female teaching professionals:

RQ1: How does prolonged standing during work hours impact a person's physical health over the years of employment?

RQ2: To what extent do the type and fit of shoes affect an individual's comfort and health when frequently moving between buildings or working long hours?

RQ3: How does general health and exercise influence an individual's well-being as they age and gain more years of work experience?

RQ4: How does lower limb health vary across different age and work-experience groups among female teaching professionals?

RQ5: Does long-term work experience contribute to discomfort while walking or changes in walking patterns of female teaching professionals?

3. Methods and Materials

To conduct a data driven analysis to analyze the walking patterns and potential gait abnormalities among female teaching professionals with the objective of answering our research questions, a survey study was conducted. data has been collected through a structured questionnaire. The questionnaire consisted of two demographic questions i.e., age and years of work experience, followed by 11 primary questions focusing on Work Habits, Physical Health and Lower Limb Symptoms.

The participants were provided with an introduction by the investigator in the Google Form with respect to how the data would be used for the purpose of fulfilling the objective of this study. Agreement to take part in the survey served as ethical approval from the participants for the usage of their data in this data driven analysis. As mentioned, the population of this data-driven analysis are f-male teaching professionals in higher education. The sample size taken as participants for this study are 46 female teaching professionals who have participated in the survey.

The structure of the Google Form used to collect the data from the participants had 4 sections namely: demography, work habits, physical health, and lower limb symptoms, and participants had to mandatorily answer all the questions. The questionnaire has been designed in such a way that the participants can select options along with an "Other" option. The survey also collects minimal demo-graphic data about the participants in order to maintain the privacy of the participants. Four questions included mutually exclusive dichotomous answers ("yes" or "no") with two of them having an additional option of "other" in case either of the two options is not matching with the participant's responses. Three questions overall have an "Other" option allowing the participant to enter their own response which is unstructured data in nature. Five questions are options-based on certain ranges, and three questions are scaled-based. One question was a multiple-choice type question.

The data contains two demographic variables, that is age (in years) and number of years the female teaching professional has been working in

academia. Along with this, we have 4 variables relating to their work habits, 3 variables relating to their physical health and 4 variables with respect to their lower-limb symptoms which are shown in Table 1.

In order to prepare the data for the data-driven analysis, the data required minimal preprocessing as all questions had predefined choices which resulted in a well-structured dataset for analysis. The data from the questions with multiple select options and which allowed participants to enter their input required preprocessing in order to calculate the frequency of each option accurately. The collected data was converted to a CSV file for preprocessing in Python using pandas library and sent to Flourish Studio [7] for visualization. In order to prepare the data for descriptive analysis, frequency distributions tables of each attribute were created since the data is primarily of categorical, so the frequency distribution table allows for a proper description of the count of female teaching professionals in each variable. In Table 1, we also describe the central tendency of each attribute, the mode in this case is included as the data collected is primarily categorical in nature. It must be noted that for the variable Shoes Worn during Work, the percentage of each category is calculated out of 46 female teaching professionals as this question is a multiple-select question.

Table 1: Frequency Distribution of Responses

Section	Variable	Option Count (%)	Mode
Demo-graphic	Age (Years)	25-34 / 16 (34.78)	35-44 Age group
		35-44 / 20 (43.48)	
		45-54 / 9 (19.57)	
		55-64 / 1 (2.17)	
		>60 / 0 (0)	
	How many years have you been working in academia?	0-5 years / 17 (36.96)	0-5 years
		6-10 years / 8 (17.39)	
		11-15 years / 6 (13.04)	
		16-20 years / 6 (13.04)	
		>20 years / 9 (19.57)	
Work Habits	How many hours per day do you typically spend standing or walking at work?	<2 hours / 3 (6.52)	2-4 hours & 4-6 hours
		2-4 hours / 15 (32.61)	
		4-6 hours / 15 (32.61)	
		>6 hours / 13 (28.26)	

Table 2: Frequency distribution of Responses (Cont.)

Section	Variable	Options Count (%)	Mode
Work Habits	How many hours per day do you spend sitting during work?	<2 hours / 6 (13.04)	2-4 hours
		2-4 hours / 17 (36.96)	
		4-6 hours / 12 (26.09)	
		>6 hours / 11 (23.91)	
	What kind of shoes do you wear during work?	Flat shoes / 41 (89.13)	Flat shoes
		Heels / 4 (8.70)	
		Orthotic inserts /1 (2.17)	
		Athletic shoes /5 (10.87)	
		Other / 3 (6.52)	
	How often do you usually walk or move between different buildings on campus during your workday?	Rarely / 2 (4.35)	Frequently
		Occasionally / 10 (21.74)	
		Sometimes / 11 (23.91)	
		Frequently / 20 (43.48)	
		Always / 3 (6.52)	

Table 3: Frequency distribution of Responses (Cont.)

Section	Variable	Options Count (%)	Mode
Physical Health	How would you rate your general physical health?	Poor / 4 (8.70)	Good
		Fair / 12 (26.09)	
		Good / 27 (58.70)	
		Very good / 3 (6.52)	
		Excellent / 0 (0)	
	How many days per week do you engage in physical exercise or activities (e.g., walking, gym, yoga)?	0 days / 10 (21.74)	1-2 days
		1-2 days / 18 (39.13)	
		3-4 days / 13 (28.26)	
		5 days / 2 (4.35)	
		Daily / 3 (6.52)	

Table 4: Frequency distribution of Responses (Cont.)

Section	Variable	Options Count (%)	Mode
Physical Health	Do you have any known conditions affecting your lower limbs (e.g., arthritis, varicose veins, plantar fasciitis)?	Yes / 12 (26.09)	No
		No / 33 (71.74)	
		Not sure / 1 (2.17)	
Lower Limb Symptoms	Have you experienced any pain or discomfort in your lower limbs (feet, ankles, knees, legs) in the past month?	Yes / 25 (54.35)	Yes
		No / 21 (45.65)	
	How would you rate the severity of your lower limb discomfort?	0 (No discomfort) / 11 (23.91)	2
		1 / 13 (28.26)	
		2 / 14 (30.43)	
		3 / 8 (17.39)	
		4 (Severe discomfort) / 0 (0)	
	Have you noticed any changes in your walking pattern (e.g., limping, uneven stride) over the recent days?	Yes / 8 (17.39)	No
		No / 35 (76.09)	
		Other / 3 (6.52)	
Do you believe your work environment or habits contribute to any lower limb discomfort?	Yes / 18 (39.13)	Yes	
	No / 17 (36.96)		
	Not sure / 11 (23.91)		

3.1 Descriptive Analysis

Figures 2 and 3 illustrate the distributive information of all the attributes. The figures include a bar chart of each variable describing the distribution of the data.

4. Results and Discussion

After preprocessing and basic description of the data, the data was analyzed from the perspective of the five research questions which provide a data-driven analysis on the lower-limb health and gait patterns among female teaching professionals.

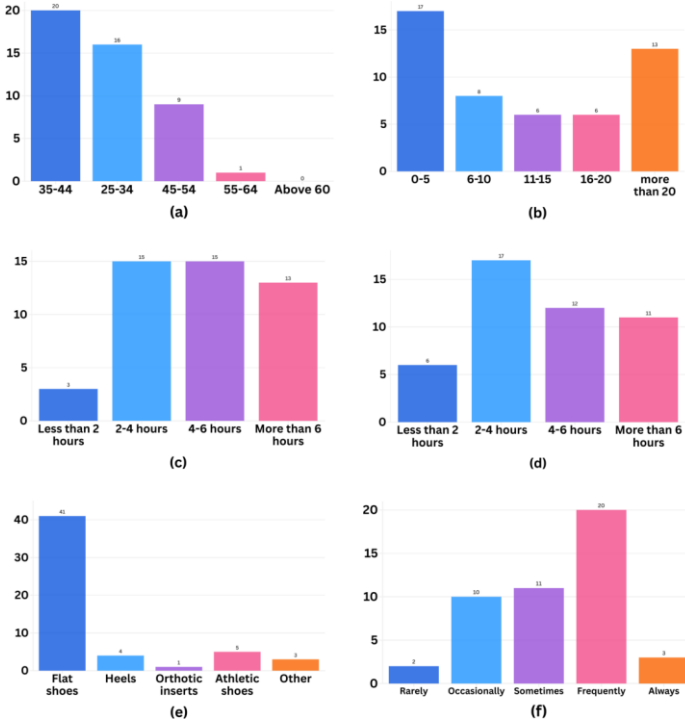


Figure 2: Frequency distribution of (a) Age Group, (b) No. of Years Working in Academia, (c) No. of Hours Spent Standing or Walking during Work, (d) No. of Hours Spent Sitting during Work (e) Type of Shoes Worn, (f) Movement Frequency

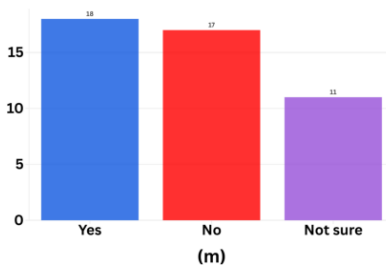
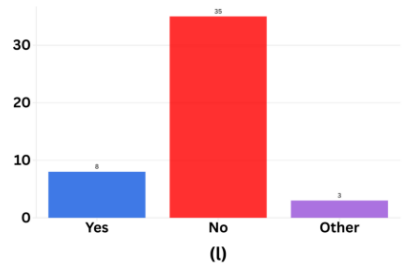
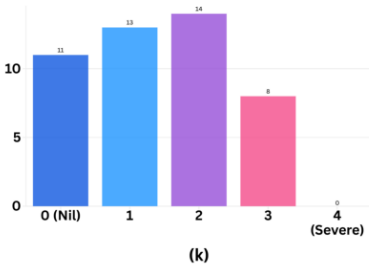
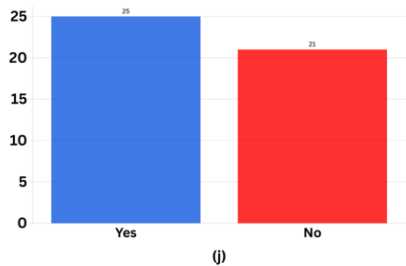
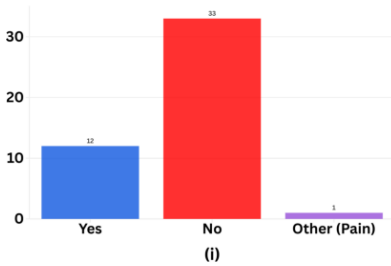
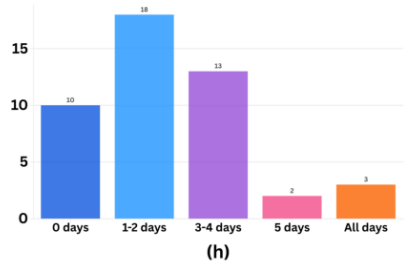
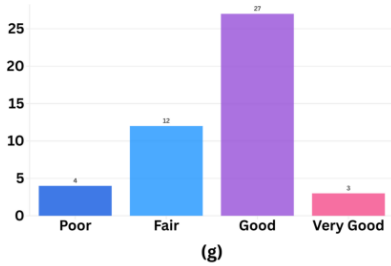


Figure 3: Frequency distribution of (g) Rating of General Physical Health, (h) Days Spent in Physical Exercise/Activity, (i) Having a Known Condition in Lower Limbs, (j) Having Pain or Discomfort in Past Month, (k) Severity Rating of Pain in Lower Limb, (l) Notice of Change in Walking Pattern, (m) Work Environment Contributing to Lower Limb Discomfort

RQ1: How does prolonged standing during work hours impact a person’s physical health over the years of employment?

An analysis of the data of the female teaching professionals grouped according to their years of experience in academia and analyzing the responses on how many hours they spend standing during work hours in a day and their response to whether or not they have been experiencing lower limb discomfort.

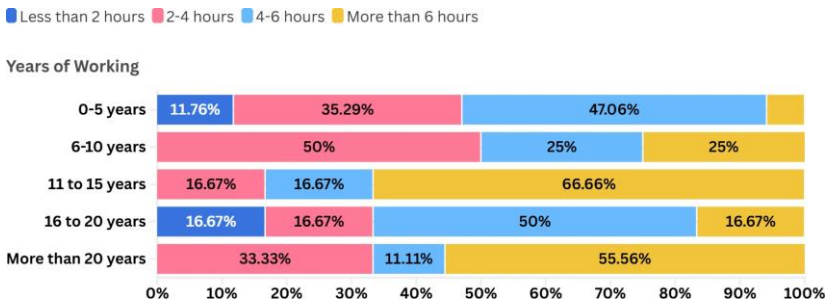


Figure 4: Distribution of Hours Female Teaching Professionals spent Standing grouped by Years of Working in Academia

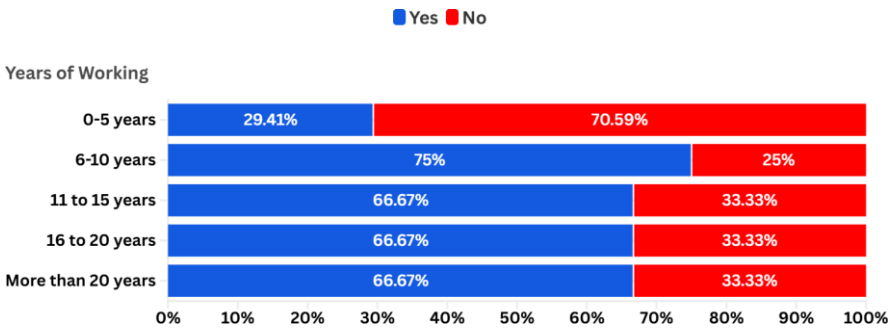


Figure 5. Percentage of Female Teaching Professionals Experiencing Pain or Discomfort in Lower Limbs

On analysing Figure 4 and Figure 5, female teaching professionals with over 11 years of experience tend to stand for 4-6+ hours daily (Figure 4), with 66.67% reporting lower-limb pain (Figure 5). Among those working for more than 20 years, 55.56% stand over 6 hours, and 66.7% experience pain. This suggests that prolonged standing over the years contributes to discomfort and potential musculoskeletal disorders.

RQ2: To what extent do the type and fit of shoes affect an individual’s comfort and health when frequently moving between buildings or working long hours?

An analysis on the type of shoes worn by the female teaching professionals along with analyzing the discomfort levels in the lower limbs of those female teaching professionals who frequently move between buildings and working long hours is required.

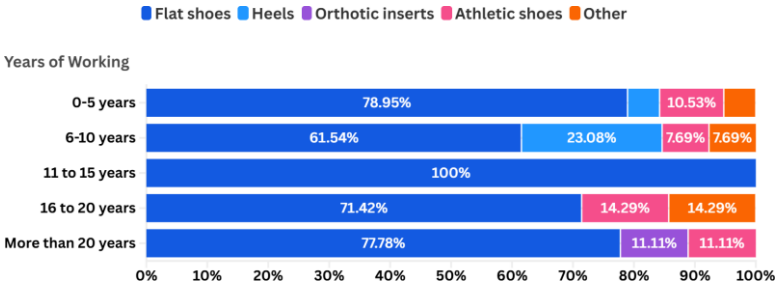


Figure 6: Percentage of Types of Shoes worn by Female Teaching Professionals grouped according to Years of Working

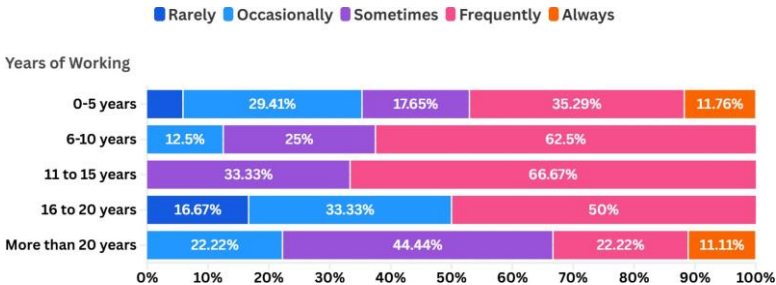


Figure 7: Percentage of Female Teaching Professionals Movement Frequency between Buildings grouped according to Years of Working

Referring to Figure 2 (e), flat shoes are the most commonly worn, but from Figure 6, 23.08% of the participants in the 6-10 years group wear heels, which correlates with 75% of female teaching professionals in the same age group experiencing pain from Figure 2. From Figure 7, a huge percentage of the female teaching professionals always and frequently move between buildings. Among participants in the 11-15 years of experience group and above, from Figure 5, we observe that 66.67% report higher discomfort, indicating that footwear choice and movement intensity significantly impact lower limb health.

RQ3: How does general health and exercise influence an individual’s well-being as they age and gain more years of work experience?

An analysis on the health ratings and exercise levels given by the female teaching professionals grouped according to their years of work experience is required.

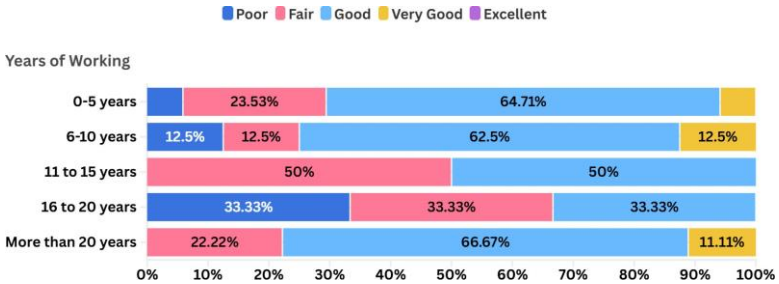


Figure 8: Percentage of Female Teaching Professionals’ Health Rating grouped by Years of Work Experience

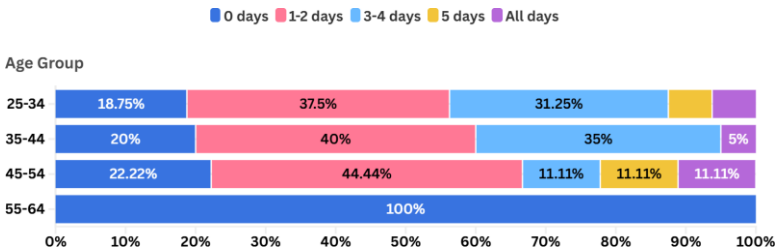


Figure 9: Percentage of Number of Days Female Teaching Professionals Exercise Grouped According to Age Group

From Figure 8, health ratings from the poor and fair categories are seen more among those teaching professionals with higher work experience, as 88.89% of female teaching professionals with 20+ years rate their health as fair or good, whereas in contrast 70.59% (64.71% + 5.88%) of female teaching professionals with 0-5 years of work experience report good or very good health. From Figure 9, exercise habits also differ, with the female teaching professionals in the age group of 55-64 report no exercise, while 31.25% of 25-34-year-olds exercise 1-2 times weekly. This suggests that maintaining an active lifestyle may help sustain better health with age.

In order to strengthen the analysis for RQ3, we evaluated the relationship proposed from the results of the aforementioned descriptive analysis. A Spearman correlation analysis was performed between the variables Exercise Frequency and rating of Overall Physical Health. The use of Spearman’s correlation as compared to Pearson’s was justified because both measures of interest were measured using an ordinal scale, requiring the use of a non-parametric test. It was found that there exists a statistically significant moderate positive correlation between the two variables ($r_s = 0.337$, $p = 0.022$, $n = 46$), where r_s denotes the Spearman correlation coefficient reflecting the strength and direction of the relationship, p represents the probability value indicating statistical significance at the conventional threshold of $p < 0.05$, and n refers to the total number of participants in the study. The conclusion that can be made is that the female teachers who exercised more often during the week have generally better physical health. Based on Cohen’s [8] guidelines, the obtained correlation coefficient of $r_s = 0.337$ indicates a moderate effect size.

RQ4: How does lower-limb health vary across different age and work-experience groups among female teaching professionals?

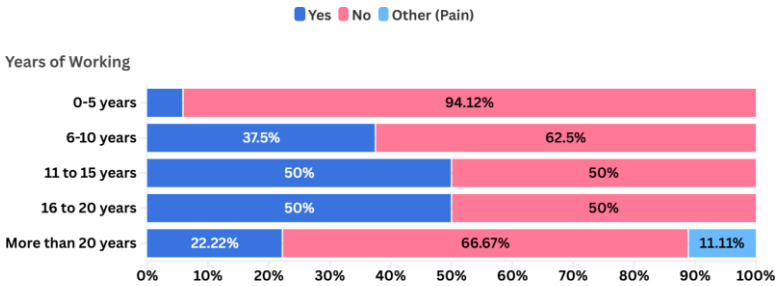


Figure 10: Percentage of Female Teaching Professionals with known conditions like arthritis, varicose veins, plantar fasciitis grouped according to Years of Working

Observing Figure 10 we see that the lower-limb conditions slightly increase with work experience, affecting only 5.9% of employees with 0-5 years of experience but rising to 37.5% in the 6-10 group and steadily rising to 50% in the 11-15 and 16-20 years of experience. In groups with 20+ years of experience only 22% reported known lower limb conditions with 11% reporting lower-limb pain only. Referring to Figure 5, pain prevalence follows a similar trend, affecting only 29.4% in the 0-5 years group but 75% in the 6-10 years group and 66.67% in the subsequent work-experience group. This suggests that many years of work experience significantly is

associated with lower-limb issues over time and this could be due to long hours of standing, walking, and frequent movement in the workplace.

RQ5: Does long-term work experience contribute to discomfort while walking or changes in walking patterns of female teaching professionals?

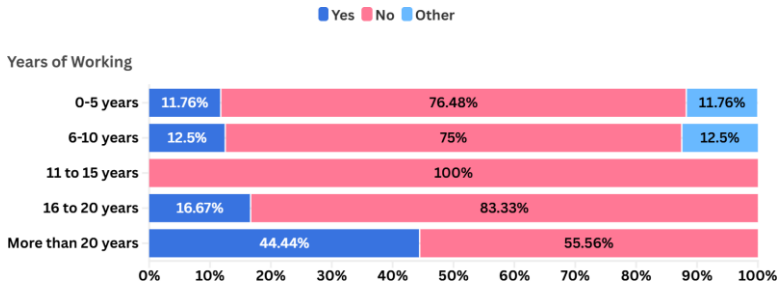


Figure 11: Percentage of Female Teaching Professionals Experiencing Changes in Walking Patterns grouped by Years of Work Experience

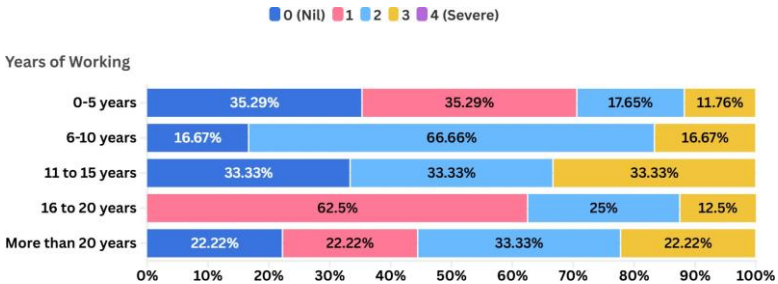


Figure 12: Percentage of Female Teaching Professionals' Rating of Severity of Pain in Lower Limb Discomfort Grouped by Years of Working

From Figure 11, we observe that changes in walking patterns are majorly reported by 44.4% of employees with over 20 years of experience. In the same pattern, from Figure 12 we observe that pain severity also increases among the female teaching professionals as their years of experience in academia increase, with 22.2% of employees in the 20+ years group reporting level 3 of pain level in lower limbs. It must be noted

that each category of female teaching professionals have experienced pain of level 3 with the group 11 -15 years of experience reporting the highest with 33.33%. Additionally, in Figure 13, we observe that 66.67% of long-term participants believe their work environment is associated with discomfort in lower limbs probably due to health issues they have experienced during their many years of service, indicating that greater work experience and age also plays a key role in walking difficulties and pain.

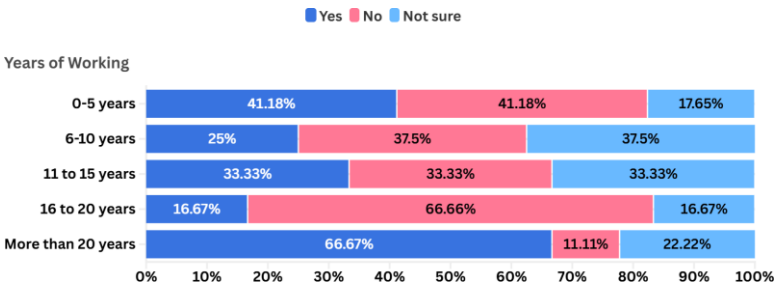


Figure 13: Percentages of Female Teaching Professionals who believe that work con-tributes to Lower Limb Issues grouped by Years of Working

The key findings of the study highlight between prolonged standing, walking, and footwear on the lower-limb health of female teaching professionals. Interpreting the results of the data-driven analysis of the survey data collected from 46 female teaching professionals, it is evident that prolonged hours of standing and walking with the advancement of both the age and years of experience of the female teaching professionals lead to discomfort in the lower-limbs over the years, with the physical activity and the type of shoes worn by the Female Teaching Professionals also affecting symptoms of pain or discomfort in the lower limbs. Also taking into account the presence of known conditions in the lower limbs, the work environment and work habits of the female teaching professionals highly impacts their gait and increase the pain and discomfort in the lower limbs.

This leads us to interpret, that certain interventions need to be made to improve the ergonomic conditions of the female teaching professionals. Especially considering, as established in the literature re-view, that variations in the gait may be a symptom of other health-related issues which could cause more problems for the female teaching professionals. A study conducted by Warmerdam et al. [9] found that continuous

monitoring and assessment of gait among patients with lower leg fractures during rehabilitation in their daily life provided data with higher accuracy, facilitating earlier detection of changes in performance and potential healing problems. This can be extended to patients with lower-limb symptoms such as the female teaching professionals of our study to monitor how the changes in their gait pattern affect their overall health.

A study on clinical gait analysis conducted by Armand et al. [10] through a review of current clinical gait analysis methods proposed a foundation for developing standardized guidelines for clinical gait analysis in Europe, addressing the current lack of international standards. In future research, this could serve as a cornerstone for developing tools to assess gait among female teaching professionals and potentially address any underlying health issues as well. Although pointed by Hummel et al. [11] in their study that the existing gait analysis technologies often face challenges such as high costs and impracticality in clinical settings, which limits their utility, however further research into the domain must be made to extend the analysis of gait among professionals to limit the prevalence of health issues related to lower limbs and other issues as well.

However, limitation from the study is the limited sample size. Future work should expand the sample size to include more female teaching professionals.

5. Conclusion

This study provides valuable insights into the relationship between workplace conditions, physical activity, and overall health, particularly concerning lower-limb discomfort. The data indicate that pro-longed standing and walking, often required in many professions, can lead increased discomfort and changes in walking patterns over time. The type of footwear also plays a crucial role, as inappropriate shoes can contribute to pain, affecting mobility and comfort. Additionally, female teaching professionals who engage in regular physical activity tend to report better overall health, reinforcing the importance of exercise in mitigating workplace-related strain. Concluding from this we find that this study can also be applied to individuals in other professions who stand for long hours so that ergonomic interventions can also be made to improve working conditions and avoid musculoskeletal disorders among employees.

These findings underscore the necessity of workplace interventions regarding ergonomics, health education, and advice on proper footwear. Proactive intervention in these issues could lead to improved employee well-being by minimizing workplace fatigue and increasing productivity.

In light of the key findings, self-regulatory practices among female teaching professionals should be undertaken by them to avoid musculoskeletal disorders. This includes but should not be limited to taking regular rest breaks, walking on cushioned flooring, and wearing proper footwear during work hours will greatly reduce discomfort and enhance long-term occupational health.

Further research can be conducted to expand the sample size of participants among female teaching professionals and also extend the study to other professions as well in similar working environments such as security guards, nurses, waiters/waitresses and restaurant staff and police constables.

Acknowledgments

The Corresponding Author, Kavitha Rajamohan, acknowledges the female teaching professionals who have agreed to participate in this survey data collection.

Author Contributions

Kavitha Rajamohan conducted the survey data collection for this study, drafted the article, and reviewed the article.

Jethro Jarvis Roy Jyrwa conducted the analysis providing data-driven insights on the collected survey data, drafted the article, and reviewed the article.

Conflict of Interest Statement

There is no conflict of interest among the authors concerning the present work.

Funding Statement

The project is a seed money project funded by CHRIST (Deemed to be University).

References

- [1]. Hulleck, A. A., Menoth Mohan, D., Abdallah, N., El Rich, M., & Khalaf, K. (2022). Present and future of gait assessment in clinical practice: Towards the application of novel trends and technologies. *Frontiers in Medical Technology*, 4:901331. doi: 10.3389/fmedt.2022.901331

- [2]. Does Prolonged Standing at Work among Teachers Associated with Musculoskeletal Disorders (MSDs)? Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 2020.
- [3]. Tahernejad S, Hejazi A, Rezaei E, Makki F, Sahebi A and Zan-giabadi Z (2024) Musculoskeletal disorders among teachers: a systematic review and meta-analysis. *Front. Public Health.* 12:1399552. doi: 10.3389/fpubh.2024.1399552
- [4]. Lev Velykoivanenko, Kavous Salehzadeh Niksirat, Stefan Te-ofanovic, Bertil Chapuis, Michelle L. Mazurek, and Kévin Huguenin. 2024. Designing a Data-Driven Survey System: Leveraging Participants' Online Data to Personalize Surveys. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems (CHI '24)*. Association for Computing Machinery, New York, NY, USA, Article 498, 1-22. <https://doi.org/10.1145/3613904.3642572>
- [5]. Ghani HA, Alghwiri AA, Hisham H, Manaf H. Lower Limb Muscle Fatigue Alters Spatiotemporal Gait Parameters and Turning Difficulty Characteristics in Parkinson's Disease. *Ann Rehabil Med.* 2023 Aug;47(4):282-290. doi: 10.5535/arm.23067. Epub 2023 Aug 9. PMID: 37558204; PMCID: PMC10475814.
- [6]. Ciprandi D, Bertozzi F, Zago M, Ferreira CLP, Boari G, Sforza C, Galvani C. Study of the association between gait variability and physical activity. *Eur Rev Aging Phys Act.* 2017 Nov 15;14:19. doi: 10.1186/s11556-017-0188-0. PMID: 29177018; PMCID: PMC5688736.
- [7]. Flourish Studio. Link: <https://flourish.studio/>
- [8]. Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.
- [9]. Warmerdam E, Wolff C, Orth M, Pohlemann T, Ganse B. Long-term continuous instrumented insole-based gait analyses in daily life have advantages over longitudinal gait analyses in the lab to monitor healing of tibial fractures. *Front Bioeng Biotechnol.* 2024 Mar 1;12:1355254. doi: 10.3389/fbioe.2024.1355254. PMID: 38497053; PMCID: PMC10940326.
- [10]. Armand S, Sawacha Z, Goudriaan M, Horsak B, van der Krogt M, Huenaerts C, Daly C, Kranzl A, Boehm H, Petrarca M, Guiotto A, Merlo A, Spolaor F, Campanini I, Cosma M, Halleman A, Horemans H, Gasq D, Moissenet F, Assi A, Sangeux M. Current practices in clinical gait analysis in Europe: A comprehensive survey-based study from the European society for movement analysis in adults and children (ES-MAC) standard initiative. *Gait*

Posture. 2024 Jun;111:65-74. doi: 10.1016/j.gaitpost.2024.04.014. Epub 2024 Apr 22. PMID: 38653178.

- [11]. Hummel J, Schwenk M, Seebacher D, Barzyk P, Liepert J, Stein M. Clustering Approaches for Gait Analysis within Neurological Disorders: A Narrative Review. Digit Biomark. 2024 May 8;8(1):93-101. doi: 10.1159/000538270. PMID: 38721018; PMCID: PMC11078540.