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Ergonomic Assessment of a Sample of Manicurists in the Metropolitan Area of Guadalajara.

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Abstract: The occupation of manicurist is crucial to the Mexican economy, contributing to the Gross Domestic Product (PIB) of the services sector. In the fourth quarter of 2023, there were 210,000 manicurists in Mexico, of which 87.5% were in the informal sector and 91.3% were women with an average age of 30 years. The lack of formality limits access to basic benefits and the healthcare system. Although manicuring may seem simple, it involves physical and mechanical risks. The absence of regulation enforcement contributes to poor working conditions. Its aim is to assess how the work system affects the presence of musculoskeletal symptoms, postural load, and repetitiveness in manicurists from the Metropolitan Area of Guadalajara who work in the informal sector, between September 2023 and October 2024. The Corlett and Bishop Body Areas Discomfort Scale was applied to 24 manicurists to identify musculoskeletal symptoms. Subsequently, two manicurists were evaluated, one expert and one inexperienced, with years of experience as the criterion. The postures of the three main tasks were analyzed with the 3DSPP software, and repetitiveness was measured using the HAL TLV and RSI instruments. The results showed that the areas of greatest discomfort were the wrists, shoulders, back, and neck, with "Severe Discomfort," while elbows and forearms presented "Important Discomfort." Regarding the workload, both manicurists experienced an imbalance in the dominant hand. The inexperienced one showed greater effort and risk, with higher scores in the dangerous tasks. Despite the postural imbalance observed in the 3DSPP, the knees were the highest-risk areas in both cases.

Keywords: Ergonomics, Physical, Repetitive Motion

1. Introduction

The occupation of manicurist represents a key sector within the Mexican PIB, with 239,000 people employed, mostly young women working in the informal sector. Although this activity is perceived as simple, it involves physical risks. The lack of labor regulations in Mexico has created precarious conditions, with no access to benefits or healthcare systems. The limited existing regulations do not meet the necessary standards for the safety of these workers. This project aims to document the effects of these conditions and promote better practices to improve health and working conditions, contributing to economic and social well-being.

1.1 Biomechanics

Biomechanics studies the forces acting on the musculoskeletal system while performing tasks (Hay, 1978), while occupational biomechanics focuses on the limitations of the musculoskeletal system during work. Evaluating whether a posture causes overload is complex, but it can be analyzed using mechanical analogies (Milburn, 1996). Musculoskeletal injuries are caused by various factors, including workspace design (Chaffin, 1987). To prevent cumulative trauma disorders, proper workstation design is essential.

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Prolonged sitting can cause lower back pain if chairs and tables are not properly selected (Chaffin, 1987; Pope et al., 1984). Work-related musculoskeletal disorders, such as Repetitive Strain Injuries (RSI) and Work-Related Musculoskeletal Disorders (WRMD), increase due to prolonged exposure to heavy loads and pose high costs for employers. These disorders depend on physical, psychosocial, and individual factors, and their prevention requires a comprehensive approach (Bernard, 1997).

Designing ergonomic tools is crucial to reduce disorders in the wrists by using ergonomic, anthropometric, and physical principles (Chaffin, 2006). Ideally, hand-held tools should minimize the force required, evenly distribute the load, and be easy to grip, improving occupational safety and health (Cohen et al., 2008).

1.2 Repetitiveness

Bernard (1997) defines repetitive movements as those performed in activities that are typically repeated in short cycles, involving quick efforts or movements of muscle groups, bones, joints, tendons, ligaments, and nerves of a part of the body, usually the upper limbs. Repetitiveness is a characteristic of the task that forces the worker to continuously repeat the same work cycle, whether it involves technical actions or movements.

2. Results

2.1 Assessment of Work-Related Body-Part Discomfort

To assess participants level of pain and discomfort, we used the body map proposed as proposed by Corlett and Bishop (1976) and Cameron (1996). The results, presented in Table 1, show a significant prevalence of severe discomfort and significant intensity in various areas of the body, reflecting the physical strain these workers are subjected to.

Table 1. Results of the Discomfort Scale by Body Region

Body Region	Average Result	Category
Neck	4.5	Severe Discomfort
Mid Back	4.25	Severe Discomfort
Cervical Region	3.75	Severe Discomfort
Upper Back	4.25	Severe Discomfort
Lower Back	4.25	Severe Discomfort
Glutes	4	Severe Discomfort
Right Shoulder	4.25	Severe Discomfort
Right Arm	4.25	Severe Discomfort
Right Forearm	4	Significant Discomfort
Right Wrist	4.75	Severe Discomfort

It was observed that the regions with the most discomfort were the wrists (with an average score of 4.75 in the right wrist), shoulders, back (middle, upper, and lower), and neck, all of which were classified in the "Severe Discomfort" category. On the other hand, areas such as the elbows and forearms had scores indicating "Significant Discomfort," suggesting that, while not as severe as other areas, these body parts are also considerably affected.

In contrast, some areas such as the left and right forearms, as well as the legs, showed lower scores, with moderate or low discomfort, which could indicate less physical impact in these areas. Nevertheless, the overall pattern indicates a high level of fatigue and physical strain, particularly in the regions most involved in tool handling and the prolonged posture associated with manicure work.

2.2 Biomechanical Assessment

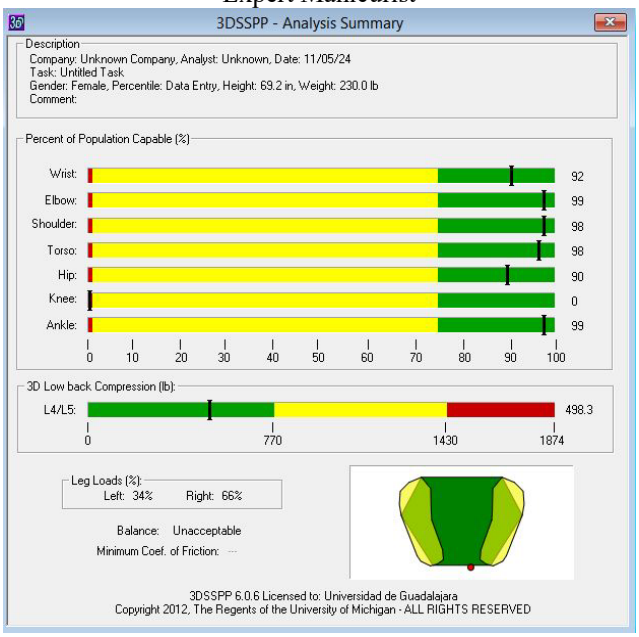
A biomechanical assessment was conducted the three most significant tasks in the application of acrylic nails: sculpting, filing, and decorating, comparing an expert manicurist and an inexperienced one. The first task analyzed was sculpting (Fig.

1). The assessment was completed following the methodology suggested Gomez-Bull et al, (2016), and the applying the 3D Static Strength Prediction Program (3DSSPP®) software, following the developer's manual (University of Michigan 2017).

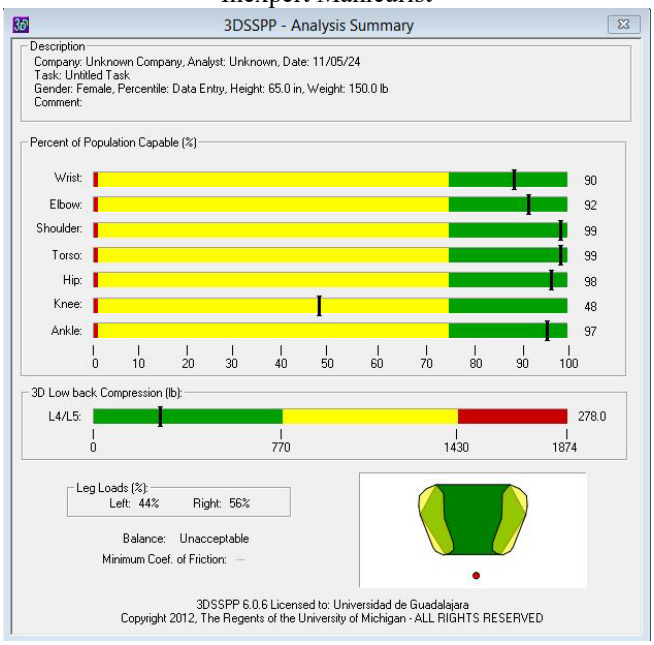
The expert's forearm rotation is -55° on the right side, outside the range of -90° to 90°. The other angular relationships of the arm are within range. In the inexperienced manicurist, the humeral rotation is 92° on the left side, also outside the range of -90° to 90°. The other angular relationships of the arm are within range. The angles for the leg, head, torso, and upper and lower leg postures are within the range for both manicurists. In the pelvis, the forward tilt of L5/S1 is 35° for the expert and 37° for the inexperienced one, both outside the 0° to 0° range. The other angular relationships of the pelvis are within the range.

Figure 1. View of the summary of the 3DSSPP program analysis of the sculpting task for both manicurists.

Expert Manicurist



Inexpert Manicurist

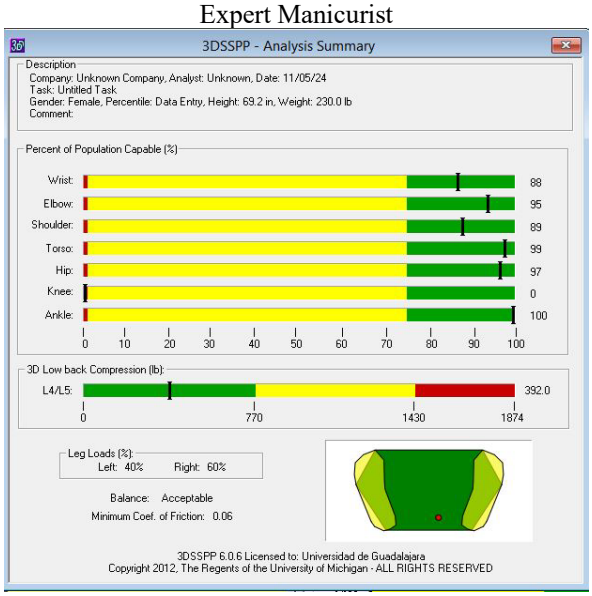


In the analysis of the filing task, the angles of the arm, upper leg, lower leg, head, and torso postures are within the range of motion limits for both manicurists.

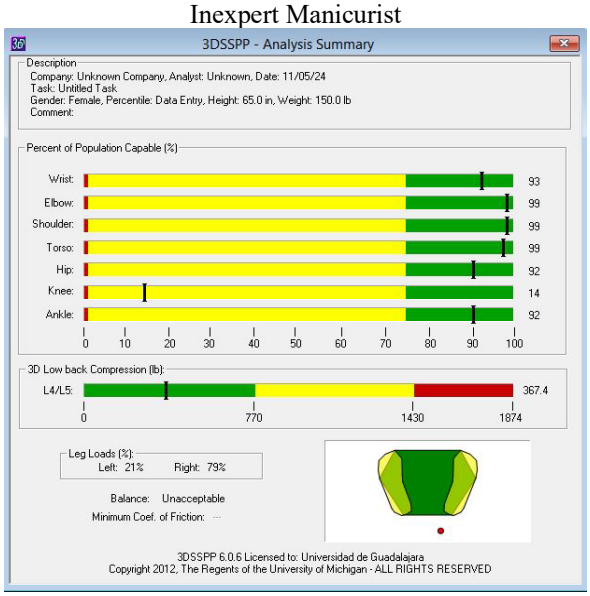
In the pelvis, the forward tilt of L5/S1 is 32° for the expert and 35° for the inexperienced one, while the range of motion limits is from 0° to 0°, which is outside the range. The other angular relationships of the pelvis are within the range of motion limits (Fig. 2).

Figure 2. View of the summary of the 3DSSPP program analysis of the filing task for both manicurists.

Expert Manicurist



Inexpert Manicurist

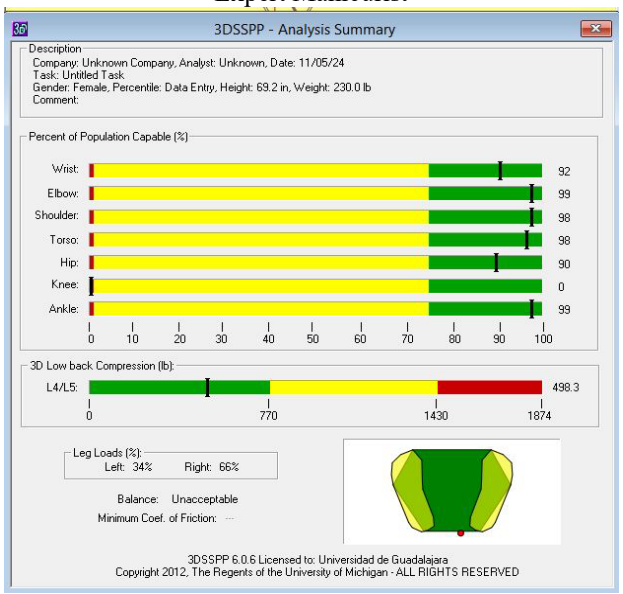


For the decorating task, the angles of the arm, upper leg, lower leg, head, and torso postures are within the range of motion limits for both manicurists. In the pelvis, the forward tilt of L5/S1 is 35° for the expert and 36° for the inexperienced one, while the range of motion limits is from 0° to 0°, which is outside the range. The other angular relationships of the pelvis are within the range of motion limits.

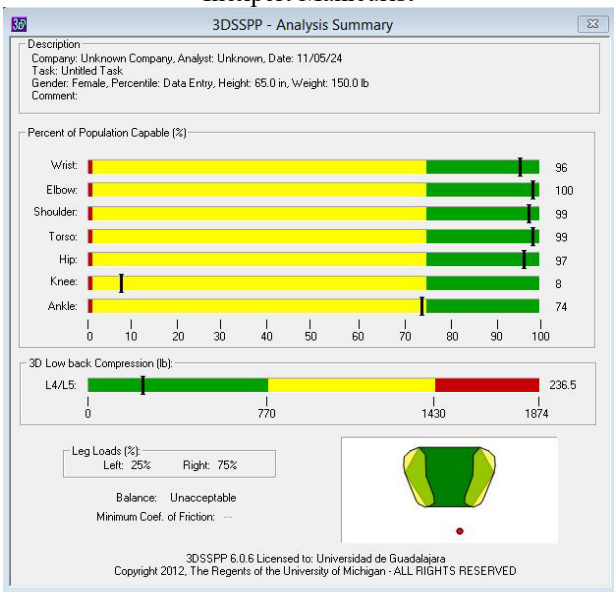
Although the analyses showed results where the posture does not raise many alerts, it is important to highlight that the program does not take into account the number of hours spent in this posture or the repetitiveness to which the upper distal limbs are subjected (Fig. 3).

Figure 3. View of the summary of the 3DSSPP program analysis of the decorating task for both manicurists.

Expert Manicurist



Inexpert Manicurist



2.3 Risk Assessment for Musculoskeletal Disorders (MSDs)

We used the Revised Strain Index (RSI) tool to assess the risk of distal upper extremity (DUE) symptoms and MSDs) (Garg et al., 2017). Results show, in the expert manicurist, all three tasks were classified as dangerous only for her dominant hand (right), reflecting a clear imbalance in the workload between both hands. This result highlights the dependence on the right hand to perform precise and detailed movements, which can only be executed with that hand.

In the inexperienced manicurist, the sculpting and filing tasks were classified as dangerous only for her dominant hand (right), also showing an imbalance in the workload. However, the scores for the dangerous tasks were nearly double, compared to those of the expert manicurist, suggesting a higher workload and greater risk for the inexperienced manicurist. This indicates that, despite the fewer tasks at risk, the inexperienced manicurist experiences more effort in tasks classified as dangerous. These results suggest that experience contributes to better technique, allowing for more effective measurement of the efforts and repetitions required to perform tasks safely (Table 2).

Table 2. Summary of the Revised Strain Index Ratings

	Sculpting				Filing				Decorating			
	Inexpert		Expert		Inexpert		Expert		Inexpert		Expert	
Factor								Right				
	Left	Right	Left	Right	Left	Right	Left		Left	Right	Left	Right
Intensity of exertion	1.57	2.62	1.57	2.62	2.62	5.02	2.62	5.02	1.57	2.62	1.57	2.62
Efforts per minute	2.6	27.78	0.1	20.1	12.6	27.78	2.6	27.78	0.1	10.1	0.1	10.1
Duration of exertion	0.45	0.45	19.05	0.45	0.45	0.45	0.45	0.45	3.55	0.45	0.45	0.45
Hand/wrist posture	1.0	1.11	1.0	1.11	1.0	1.11	1.0	1.11	1.0	1.11	1.0	1.11
Duration of the task per day	0.77	0.77	0.62	0.62	0.62	0.62	0.2	0.2	0.7	0.7	0.77	0.77
RSI	1.41	27.99	1.85	16.3	9.2	43.18	0.61	13.03	0.39	9.25	0.05	10.17

2.4 Assessment of Hand-Level Motion Repetitiveness and Effort

To assess the level of motion repetitiveness and physical effort at hand level, we used the Hand Activity Level (HAL) tool developed by the American Conference of Governmental Industrial Hygienists (ACGIH®), following the recommendation of Wurzelbachet et al. (2010). In both groups of manicurists, the dominant hand (right) experiences greater effort, with the expert manicurist approaching the risk limits in all tasks (especially in filing), while in the inexperienced manicurist, both hands remain within lower and safer effort levels. An imbalance in the workload is observed, with the right hand consistently bearing greater effort (Table 3).

Table 3. Summary of the HAL TLV

	Sculpting				Filing				Decorating			
	Inexpert		Expert		Inexpert		Expert		Inexpert		Expert	
Factor												
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
HAL	1	5	1	4	2	7	1	7	1	4	1	5
NPF	1	2	1	2	2	4	2	4	1	2	1	3

3. Conclusions

Working conditions in the manicure sector in Mexico are precarious, characterized by informality and a lack of proper regulation, which results in a high level of physical discomfort among workers, especially in areas such as the wrists, shoulders, back, and neck. The absence of labor safety regulations highlights the urgent need to implement ergonomic measures and regulations that improve health and working conditions in this sector. An ergonomic and biomechanical approach is key to preventing musculoskeletal disorders, as the proper design of workstations, taking into account posture, force distribution, and the correct choice of tools, can significantly reduce the risks associated with repetitive work and forced postures. In this sense, posture and movement analyses show that repetitive work and the lack of ergonomics contribute to fatigue and muscle pain, emphasizing the need to make adjustments in the work environment.

The analysis also reveals that experienced manicurists tend to distribute the workload better between both hands, allowing them to perform tasks more efficiently and with less effort. In contrast, inexperienced manicurists face greater effort, especially in tasks classified as dangerous, increasing their risk of injury. This underscores the importance of training workers in proper techniques to minimize physical effort and the risk of long-term damage. Although some postures and movements are within the appropriate range, repetitiveness and fatigue caused by prolonged postures continue to be risk factors for musculoskeletal disorders. Therefore, it is essential to incorporate preventive practices, such as regular breaks, task rotation, and ergonomic adjustments in workstations, to reduce these risks and protect the health of workers. This article is part of a broader study that included other factors of the work system related to the working conditions of manicurists.

Improving working conditions in the manicure sector would benefit the health, productivity, and well-being of workers. It is necessary to implement stricter regulations, promote ergonomic tools, and educate workers on proper posture and injury prevention to create a safer and healthier environment.

4. References

Bernard, B. P. (Ed.). (1997). Musculoskeletal disorders and workplace factors: A critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back (DHHS (NIOSH) Publication No. 97B141). National Institute for Occupational Safety and Health. https://certisafety.com/pdf/mdwf97-141.pdf

Cameron, J. A. (1996). Assessing work-related body-part discomfort: Current strategies and a behaviorally oriented assessment tool. *International Journal of Industrial Ergonomics*, *18*(5-6), 389-398.

Chaffin, D. B., Andersson, G. B., & Martin, B. J. (2006). Occupational biomechanics. John Wiley & sons.

Chaffin, D. B. (1987). Occupational biomechanics—a basis for workplace design to prevent musculoskeletal injuries. Ergonomics, 30(2), 321-329. https://doi.org/10.1080/00140138708969714

Cohen, A., Biederman, M., & Scharlach, A. (2008). Health and safety in the workplace: Ergonomics and Human Factors. Wiley.

Corlett, E. N., & Bishop, R. P. (1976). A technique for assessing postural discomfort. *Ergonomics*, *19*(2), 175-182.

Garg, A., Moore, J. S., & Kapellusch, J. M. (2017). The Revised Strain Index: an improved upper extremity exposure assessment model. *Ergonomics*, *60*(7), 912-922.

Gómez-Bull, K. G., Hernández-Arellano, J. L., & Ibarra-Mejía, G. (2015). A proposed methodology for task analysis in ergonomic evaluations. *Procedia Manufacturing*, *3*, 4756-4760.

Hay, J. G. (1985). The biomechanics of sports techniques. Prentice-Hall. *Englewood Cliffs, NJ [Google Scholar]*.

Pope, M. H., Johnson, R. J., Fischer, R. A., Arvidsson, I., & Eriksson, E. (1984). The biomechanics of anterior cruciate ligament rehabilitation and reconstruction. The American Journal Of Sports Medicine, 12(1), 8-18. https://doi.org/10.1177/036354658401200102

University of Michigan Center for Ergonomics. (2017). *3D static strength prediction program™ version 7.0.0 user's manual*. https://c4e.engin.umich.edu/assets/3DSSPP-Version-7.0.0-Manual.pdf

Wurzelbacher, S., Burt, S., Crombie, K., Ramsey, J., Luo, L., Allee, S., & Jin, Y. (2010). A comparison of assessment methods of hand activity and force for use in calculating the ACGIH® Hand Activity Level (HAL) TLV®. *Journal of occupational and environmental hygiene*, *7*(7), 407-416.