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Original Research

Analysis of Individual and Biomechanical Risk Factors Associated with Musculoskeletal Disorders in Online Motorcycle Taxi Drivers

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ABSTRACT

Background: Online motorcycle drivers are faced with accidents and occupational health risks when driving, one of which is Musculoskeletal Disorders (MSDs), which can interfere with comfort and focus when driving and can result in accidents. This study aims to analyze individual and biomechanical factors affecting MSDs in online motorcycle taxi drivers. **Methods:** This is a cross-sectional study with an observational-analytic research design. A questionnaire was used to obtain data on individual and biomechanical factors. The Nordic Body Map (NBM) questionnaire instrument was used to assess MSDs complaints. **Results:** The most commonly reported slight pain was in the right shoulder (56.7%), waist (55.0%), and upper neck and back (each 53.3%). The majority of online motorcycle drivers (76.7%) experienced low-level complaints. All individual and biomechanical factors have a positive relationship with MSDs complaints in online motorcycle drivers. **Conclusions:** Drivers must pay attention to their nutritional needs, stop smoking, and stretch 1-2 times a day regularly between work hours.

Keywords: Biomechanical phenomena; persons; musculoskeletal diseases; motorcycles

1. INTRODUCTION

Technological advancements worldwide have had a profound impact on various aspects of human life. One of these is the transportation sector. In developing countries, one form of transportation that has grown rapidly as a result of these technological developments is the use of online motorcycle taxis. The presence of online motorcycle taxi drivers in developing countries such as Indonesia has many advantages in terms of helping the economy and work processes.

People can get to work faster by using online motorcycle taxi drivers. Additionally, orders for necessary goods can be delivered promptly through this service. In other circumstances, online ride-hailing drivers face health risks such as MSDs.[1] These negative effects arise because online ride-hailing work is not considered formal employment. Drivers often work long hours, face stressful conditions, and receive low incomes.[2]

One of the occupational diseases based on the target organ system mentioned by the ILO is musculoskeletal disorders.[3] MSDs are complaints of the skeletal muscles ranging from mild to severe, including damage to joints, ligaments, and tendons or disruptions of normal musculoskeletal function.[4] These conditions result from risk factors that include biomechanical factors (body posture while working, workload, duration of work, and exposure to vibration) and individual factors (age, gender, BMI, smoking habits, exercise habits, and length of employment).[5,6] Complaints in the musculoskeletal system generally occur due to excessive muscle contraction from heavy workloads with prolonged periods of exertion. When muscle contraction exceeds 20%, blood flow to the muscles decreases, resulting in a reduced oxygen supply to the muscles.[7] This impairs carbohydrate metabolism and leads to lactic acid buildup, causing muscle pain.[8]

Based on the results of a report provided by the International Labour Organization (ILO), nearly 160 million work-related health disorders occur worldwide each year. Among these health disorders, MSDs are the second most common type of health disorder generally experienced by workers around the world.[9,10] Several studies have shown a correlation between individual factors and biomechanical factors and the occurrence of MSDs in workers who use motorcycles as their primary means of transportation for work. In terms of working hours, uncomfortable posture, repetitive movements, and driver age are associated with the occurrence of MSDs. Each additional hour of work per week increases the risk of pain in the neck, shoulders, upper back, and thighs.[1] Studies conducted in Vietnam show that online motorcycle taxi drivers with abnormal BMI have a higher risk of traffic accidents.[11] These accidents are preceded by driving discomfort due to MSDs. Other research on online motorcycle taxi drivers has shown that significant risk factors for MSDs include advanced age, irregular physical activity, driving duration (> 8 hours per day), length of service (≥5 years), and poor driving posture.[12]

This study is important to prevent MSDs among online motorcycle taxi drivers as informal workers in Indonesia. Attention to this occupation will have an impact on the welfare of small community groups. This study aims to analyze individual and biomechanical factors as risk factors for MSDs among online motorcycle taxi drivers.

2. METHODS

2.1 Study Design

This study is a quantitative study with a cross-sectional design. In this design, the researcher collects data on dependent and independent variables simultaneously at the same time. The study was conducted in the city of Surabaya, Indonesia, from December 2021 to April 2022. The dependent variable is MSDs, and the independent variables are individual factors and biomechanical factors. This type of research is an analytical observational study. The researcher did not administer any treatment to the respondents.

2.2 Population

The population in this study consisted of online motorcycle taxi drivers in Surabaya. These drivers were members of the Ngakak Grab Rungkut community and the Independent Community, which had a total of 60 drivers. The sample in this study was the total population.

2.3 Data Collection

Data were collected using questionnaires and Nordic Body Map (NBM) assessment sheets. Questionnaires were used to obtain data that became independent variables in the study. Data related to individual factors included age, gender, smoking habits, length of service, BMI, and exercise habits. Biomechanical factor data consisted of vehicle type and driving duration. The NBM sheet was used to assess workers' subjective complaints of musculoskeletal disorders (MSDs).

2.4 Data Analysis

Data analysis was conducted through editing, coding, and tabulating processes. The editing process was carried out to ensure that the data obtained were in line with the research requirements. Coding involved assigning an identity to grouped data. Tabulation is the process of entering data into tables for subsequent data

analysis. The entire data analysis process utilized SPSS (Statistical Product and Service Solutions) software version 21. The strength of the relationship was analyzed using the contingency coefficient test for nominal data scales and the Spearman rank correlation coefficient test for ordinal data scales.

The degree of closeness of the relationship between variables from the correlation analysis can be seen with a correlation coefficient ranging from -1.0 to 1.0. A negative value indicates that if variable X increases, variable Y will decrease. The closer the coefficient value is to -1, the more negative the relationship between variables X and Y. Meanwhile, a positive polarity indicates that if variable X increases, variable Y will also increase. The closer the coefficient value is to 1, the more positive the relationship between variables.

2.5 Ethical Practices

This study has been approved by the Ethics Committee of the Faculty of Public Health, Universitas Airlangga (Reference Number: 69/EA/KEPK/2022). The research process was approved by the respondents prior to data collection. The research objectives, rights, and obligations of the respondents were explained by the researcher. Participation in this study is voluntary. Respondents have the right to withdraw at any time without any consequences.

3. RESULTS

The results of MSDs complaints assessment using the NBM in Figure 1 show that the body parts that were most slightly painful were the right shoulder (56.7%), waist (55.0%), and upper neck and back, each at 53.3%. The body parts that were most painful were hips (18.3%) and waist (15.0%). The body parts that were described as very painful were the buttocks (3%), left shoulder, back, and right upper arm, each at 1.7%.

Complaints experienced by online motorcycle drivers in Figure 2, the majority of online motorcycle drivers (76.7%) experience low complaints. MSDs' complaints experienced by online motorcycle drivers in Figure 3, medium and high complaints were experienced more by drivers aged less than 35 years, 25.0% and 4.2%, respectively. The contingency coefficient value is 0.174, indicating a weak positive relationship. Medium and high MSDs complaints were mostly experienced by drivers with BMI Obesity I, by 31.3% and 6.3%, respectively. The correlation coefficient value is 0.079, indicating a very weak positive relationship. Thus, the higher the BMI value, the higher the MSDs complaints.

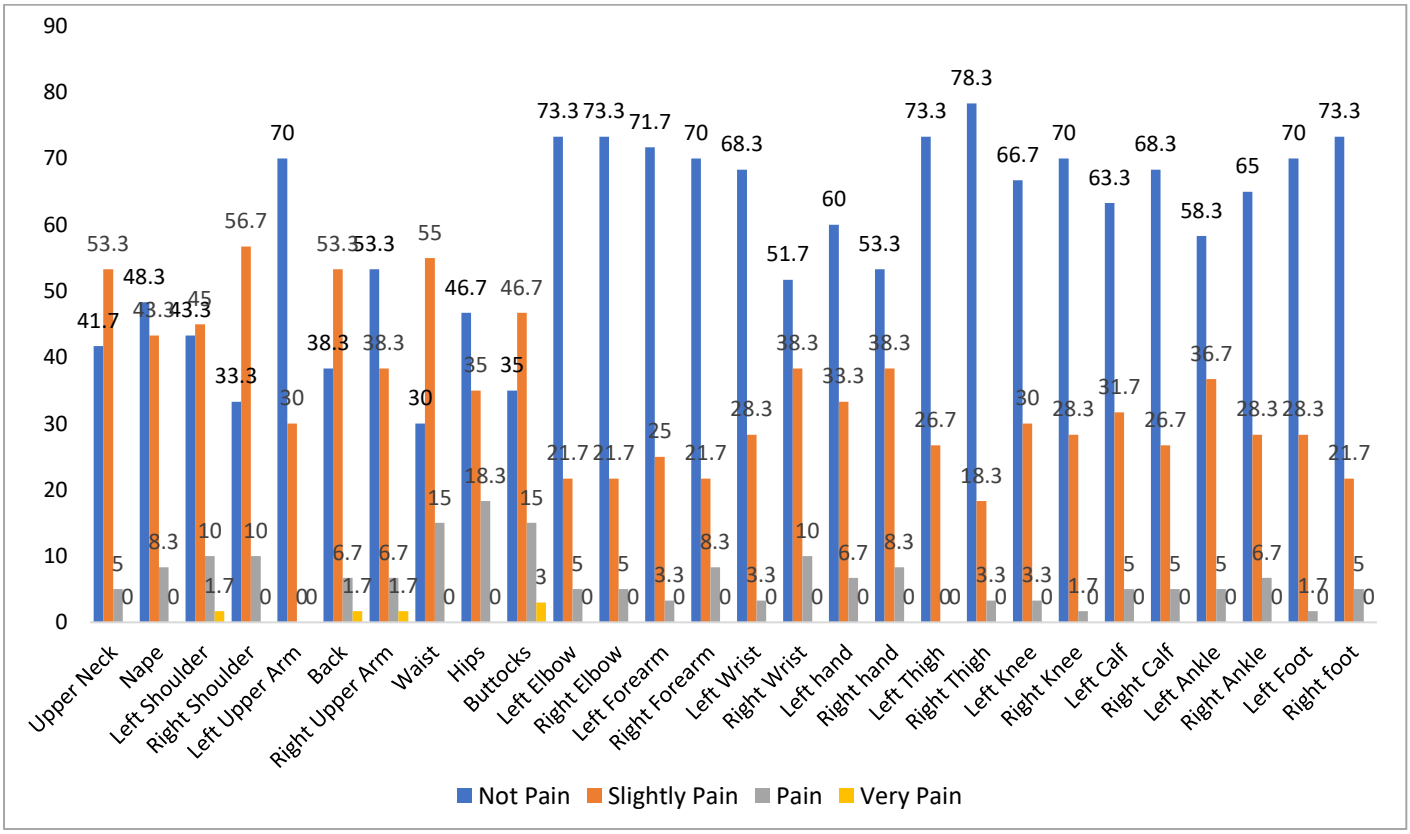

Figure 1. MSDs complaints in body parts based on NBM assessment

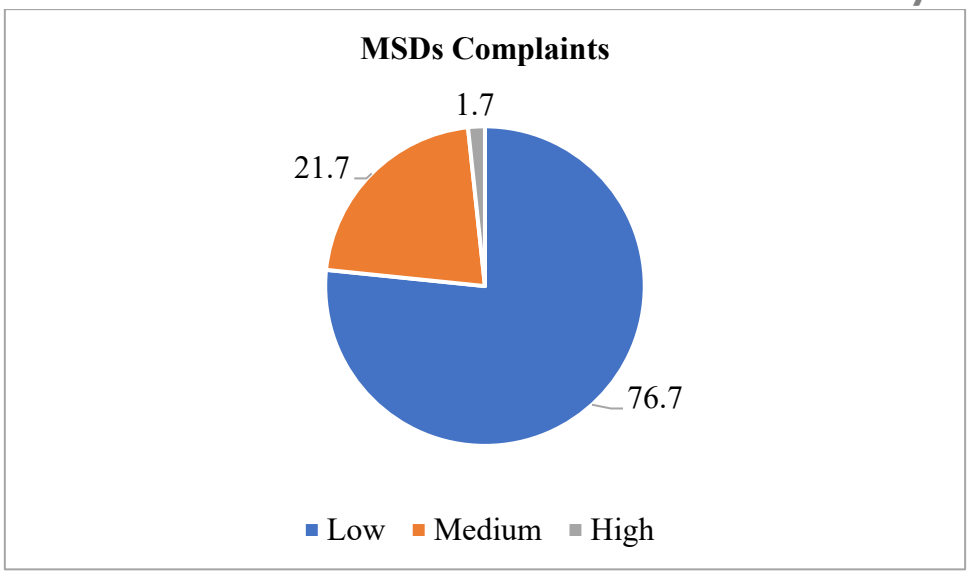

Figure 2. MSDs complaints experienced by online motorcycle drivers based on NBM assessment

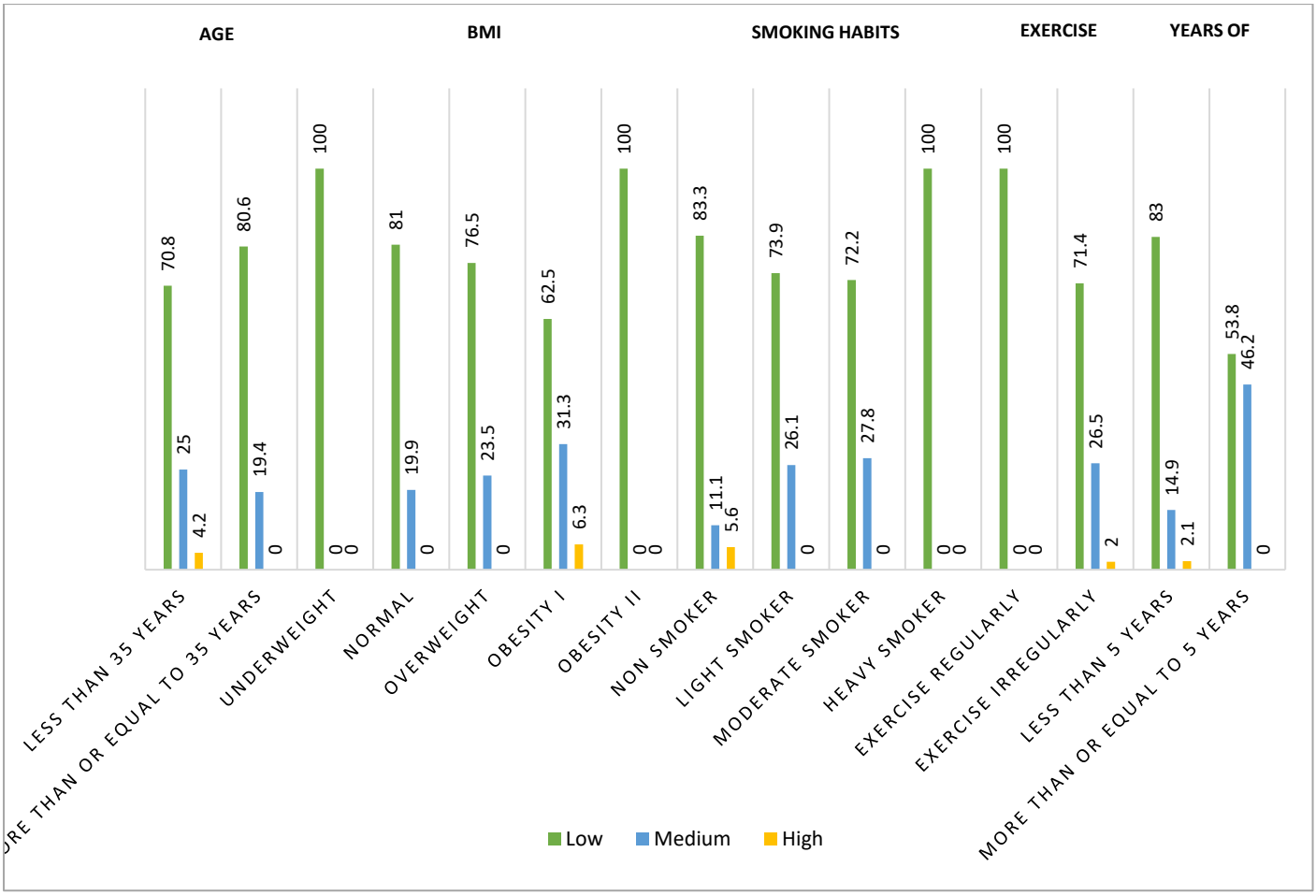

Figure 3. MSDs Complaints based on Individual Factors

Medium MSDs complaints were mostly experienced by moderate smokers (27.8%), and high MSDs complaints were mostly experienced by non-smokers (5.6%). The correlation coefficient value is 0.069, indicating a very weak positive relationship. So, the higher the smoking habit, the higher the MSDs complaints. All online motorcycle drivers who exercise regularly experience low MSDs complaints. Medium and high MSDs complaints were experienced by online motorcycle drivers who exercise irregularly, at rates of 26.5% and 2.0%, respectively. The contingency coefficient value is 0.253, which is a weak positive relationship. Most

high MSDs complaints were experienced by online motorcycle drivers with less than 5 years of service (2.1%). Most medium MSDs complaints were experienced by online motorcycle drivers with more than or equal to 5 years of service (46.2%). The contingency coefficient value is 0.301, which is a fairly strong positive relationship. So, the longer the years of service, the higher the MSDs complaints.

In Figure 4, medium to high complaints are experienced by online motorcycle drivers with automatic motorcycles, 23.5% and 2.0%, respectively. The contingency coefficient value is 0.129, which is a weak positive relationship. Medium MSDs complaints are mostly experienced by online motorcycle drivers with a driving duration of more than 8 hours/day (25%), and high MSDs complaints are mostly experienced by online motorcycle drivers with a driving duration of less than or equal to 8 hours/day (1%). So, there is no tendency for drivers with a driving duration of more than 8 hours to experience more MSDs complaints than online motorcycle drivers with a driving duration of less than or equal to 8 hours/day. The contingency coefficient value is 0.144, which is a weak positive relationship. So, the longer the driving duration, the higher the MSDs complaints.

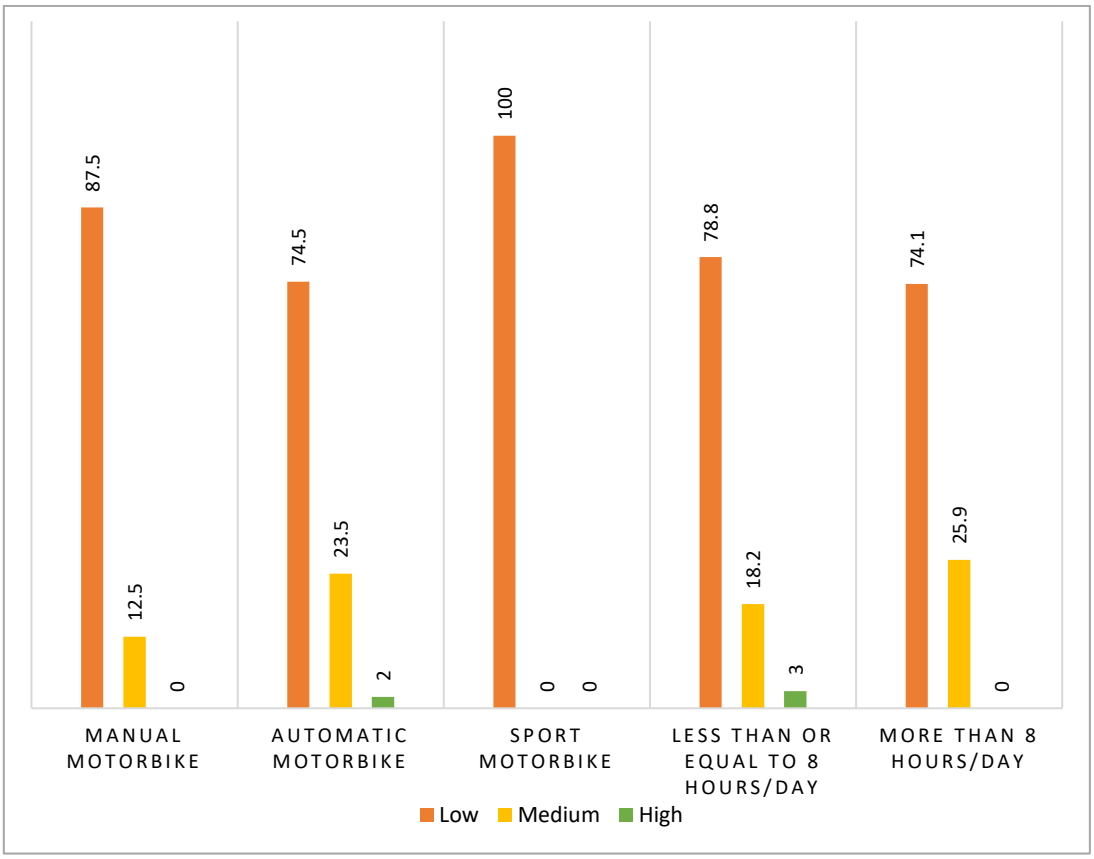

Figure 4. MSDs complaints based on biomechanical factors

4. DISCUSSION

Musculoskeletal disorders are human musculoskeletal system disorders including muscles, tendons, cartilage, skeleton, vascular system, ligaments, and nerves. In this research, the majority of online motorcycle drivers experienced low complaints (76.7%) and the body parts that were most commonly complained of for pain were the right shoulder, waist, upper neck, back, buttocks, hips, left shoulder and right upper arm. Many online motorcycle drivers complained of pain in several parts of the right side of the body. This is because the right side of the body, especially the upper part, such as the right shoulder and right upper arm, has more control over steering the motorcycle, such as speed control on the right handle of the motorcycle. Research by Nurhafizhah et al. (2018) on online motorcycle drivers found MSDs complaints in the lower back, buttocks, neck and wrists.[13,14] Another research by Rezaei et al. (2024) on market labor workers, showed 74.7% experienced MSDs complaints, most commonly experienced in the shoulders and back.[15] Meanwhile, the most common

prevalence of MSDs in motorcycle drivers in Cameroon is in the spine, wrist and shoulder.[16]

Tarwaka (2015) states that maximum muscle strength occurs at the age of 20 to 29 years and at the age of 60 years, muscle strength decreases by 20%.[17] The older a person is, the lower the muscle strength in his body. A degenerative process occurs, with tissue regeneration into scar tissue which affects muscle elasticity, damage to other tissues, and decreased fluid which results in disruption of muscle and bone stability.[18] There is a weak relationship between age and MSDs complaints in online motorcycle drivers in this research. Age is related to MSDs complaints experienced by a person and complaints increase with age.[17] Age is a risk factor for MSDs.[16] Age can be a major cause triggering muscle complaint, because as age increases, muscle capacity decreases. In line with research by Russeng et al. (2021), there is a relationship between age and MSDs complaints in nurses. Nurses aged more than 35 years experience many complaints of MSDs and are at serious risk.[18] Other studies have also shown that there is a relationship between age and MSDs complaints in hauling workers.[14,19] The MSDs complaints prevalence increases with age. They are generally experienced at the age of 30 to 35 years. Increasing age is followed by a decrease in maximum oxygen consumption, resulting in a decrease in work capacity which is characterized by physical fatigue or muscle weakness. Muscles need oxygen and adequate blood supply for metabolic processes and to regulate muscle contractions. If oxygen intake and blood supply are disrupted, muscle fatigue causes the muscles unable to be contract even though stimulation from motor nerves is still running.[20]

Based on the theory by Hernandez and Peterson (2012), there is a relationship between body mass index and MSDs complaints.[13] Correspondingly, in this research there was a very weak positive relationship between BMI and MSDs complaints, indicating MSDs complaints increased with increasing body mass index. This is in line with Tarwaka (2015), body mass index has relatively little effect on MSDs complaints, but can still cause MSDs complaints.[17] Other studies support this, there is a significant relationship between BMI and MSDs complaints in welding operator workers.[21] Research by Rahmawati (2020) on freight forwarders showed there is a relationship between BMI and MSDs workers' complaints.[22] Workers with abnormal BMI have a tendency to increase mechanical stress due to gravity on the musculoskeletal system, resulting in fatigue and musculoskeletal disorders, especially in extremities below the knee. This increased mechanical stress is usually on the lower extremities or back. Meanwhile, from this research, only a small proportion of online motorcycle drivers experienced knee complaints. This can be due to different job characteristics. There are also other factors, such as increased metabolic factors such as LDL and cholesterol.[23]

Smoking habits are an MSDs complaints risk factor.[13] In this research, there was a tendency for online motorcycle drivers who were heavy smoker to experience higher MSDs complaints with a very weak relationship. Research by Hanif (2020) on lift workers found there is a relationship between smoking habits and MSDs complaints. MSDs complaints increase as smoking habits increase.[24] Other research states that there is a significant relationship between smoking habits and MSDs complaints on the back, shoulders, elbows, and knees in smokers and former smokers.[25] Smoking habits are a risk factor for MSDs complaints related to the nicotine content in cigarettes. Nicotine causes reduced blood flow to the tissues. Smoking habits cause reduced mineral content in the bones, causing fractures and bone damage, which then causes pain. Smoking habits can interfere with lung function in absorbing oxygen for the body's metabolism. Viester et al. (2013) stated that metabolic disorders can also be a risk factor for MSDs complaints, especially in the upper body.[23] Online motorcycle drivers also experience a lot of complaints in the upper body such as the shoulders, arms, upper neck and back. Smokers are more likely to have back problems than non-smokers.[21]

Exercise habits are related to physical fitness. Exercising regularly can prevent obesity and its negative effects, give strength, make the muscles activities in the body such as respiratory muscles, heart muscles, and skeletal muscles work more efficiently. It can expedite blood flow into cells, body tissues, and improve waste substances removal from cells to be better. Tarwaka (2015) stated that individuals with a low level of body fitness are experiencing muscle complaints risk by 7.1%, individuals with a moderate level are 3.2%, and individuals with high level are 0.8%.[17] In this research, there is a tendency for online motorcycle drivers who exercise irregularly to experience higher MSDs complaints, with a weak positive relationship. In line with Russeng et al. (2021), most nurses who exercise irregularly experience MSDs complaints.[18] Abledu et al. (2014) also stated that low exercise activity is associated

with an MSDs complaints increased risk.[14] According to the research, welding operators who don't have exercise habits are potentially 0.03 times more likely to experience MSDs than operators who have exercise habits.

Years of service are related to MSDs complaints, related to continuous static loads and repetitive movements as part of work characteristics. Years of service are a risk factor for MSDs.[15] The longer the years of service, especially in jobs that require high muscle strength, the musculoskeletal system disorders risk is higher.[26] In this research, drivers with more than or equal to 5 years of service tended to experience higher MSDs complaints than drivers with less than 5 years of service, with a fairly strong relationship. Research by Arini and Haqi (2021) showed craftsmen with years of service more than 3 years experience musculoskeletal disorders complaints at a high to very high risk level.[27] Because the longer the years of service, the longer the exposure at work, the MSDs risk is higher. MSDs complaints can increase if the years of service also increases and they will experience physical and psychological boredom. From this research, muscle disorders appeared 2 years after working with the same type of work. The same work is defined as work that uses the same muscles for a long time or more than 2 hours.

Online motorcycle drivers in this research work on motorcycle. There is a weak positive relationship between motorcycle type and MSDs complaints. Drivers with automatic and sports motorcycle types have a higher risk of MSDs complaints than drivers with manual motorcycle types. Motorcycle manufacturers are more concerned with design aspects than ergonomics when designing motorcycles. Some designs are considered to be less ergonomic so that the rider's posture becomes unnatural and causes discomfort which can lead to traffic accidents.[14] In all three types of motorcycle, there is no seat width, seat height, seat length, seat tilt, which is ideal in comparison to the driver's anthropometry. Ergonomic risks posed are a lack of support in supporting the thighs when sitting and pressure on thighs and hips which affects the smooth circulation of blood, causing tingling and fatigue in the legs. In terms of slope, manual and automatic motorcycles are close to ideal.[14] The sports motorcycle type is considered too oblique. An incorrect posture arising from the tilting of the rider's seat cushion results from a bending motion (flexion). A bent position creates large compression forces between spinal discs, especially at lumbar 5 and lumbar 5 (moving anteriorly). If it occurs continuously, it causes pain in the lower back area due to pressure on the nervous system in the spine. Long-term flexion positions also cause intervertebral stress and intradiscal pressure on the rider's lumbar and thorax. In addition, this sitting posture can tire the waist muscles. Improper posture for a long time can also cause MSDs. In addition, the fatigue level in muscles when driving is caused by the long effort to maintain posture and when maintaining balance while driving. Research by Ramadhan et al. (2025) shows sport motorcycles provide a greater increased risk of musculoskeletal disorders than manual and automatic motorcycles.[28] Automatic motorcycles are the motorcycle type with the best anthropometric compatibility with Indonesian anthropometry. Wójcik and Trybulec (2017) also stated that sports motorcycle drivers are at a higher risk of experiencing complaints in the neck. Because the body position leans forward and puts more pressure on the driver's neck to look forward.[29]

Prolonged use of two-wheeled vehicles can cause musculoskeletal disorders. Two-wheeled vehicle riders are prone to experiencing musculoskeletal disorders in the lower back, upper back, shoulders and neck.[28] Research on online motorcycle drivers in Kendari found that there was a relationship between work duration and complaints of MSDs.[30] In this research, there was a weak positive relationship between driving duration and MSDs complaints, in which MSDs complaints increased with driving duration. In line with research by Abledu et al. (2014) driving more than 12 hours a day or at least 5 days a week is significantly associated with an increased risk of MSDs complaints.[14] Other research states that workers with a working duration of more than 8 hours experience many MSDs complaints, especially low back pain and Carpal Tunnel Syndrome (CTS).[31] Workers' productive working time in a day is generally 6-10 hours and the remaining 14-18 hours are used for rest or gathering with family and community. In one week people can only work well for 40-50 hours. Work that uses the same muscles for a long duration can increase the potential for fatigue and cause MSDs if rest/recovery time is insufficient. The longer the duration of carrying out risky work, the longer the time required for recovery will also be.[32] Many online motorcycle drivers in this research experienced complaints in the right shoulder, waist, upper neck, back, buttocks, hips, left shoulder and right upper arm. Likewise, sitting for too long causes excessive burden on the lumbar vertebrae, causing pain in the lower back. An unergonomic sitting position makes the back muscles work hard to withstand the load

on the upper limbs. As a result, the workload rests on the waist area as the main load-bearing. Thus, it is easy to experience fatigue and pain in the lower back muscles. Abledu et al. (2014) stated that sitting in a static body position for a long time on a vehicle causes postural tension in the musculoskeletal system.[14] This creates discomfort for the driver, thereby increasing the risk of injury to the musculoskeletal system. Wójcik and Trybulec (2017) found that neck pain complaints were positively related to driving duration.[29] The time spent by respondents as online motorcycle drivers shows that motorcycles are a very important element to support their activities in looking for passengers spread from various points. The reason they force themselves to pursue the top target or points set by the company in order to get a high monthly salary is the reason respondents are willing to sit for hours on a motorcycle as online motorcycle drivers. Based on this, it is necessary to take time to take small breaks, at least for stretching, because if the duration factor is combined with the repetition factor, then duration will be a risk factor for the occurrence of MSDs symptoms because repetitions are done more than 4 times in 1 minute for more than 2 hours which can cause muscle fatigue. As stated by Diatta et al. (2020), work duration is a risk factor for MSDs.[16] The longer the duration of work or the longer a person is exposed to the risk of MSDs, the greater the risk of experiencing Musculoskeletal Disorders complaints.

A limitation of this study is that data collection on MSDs complaints using the NBM questionnaire was conducted at a single point in time. Data collection did not take into account the time after driving, so the complaints they felt may have disappeared. Drivers also had difficulty remembering the complaints they felt while driving or after driving.

5. CONCLUSION

All individual factors and biomechanical factors are positively related to MSD complaints in online motorcycle drivers. One of the factors that is quite strongly related to MSD complaints is years of service. Moderate MSD complaints are experienced by the majority of online motorcycle drivers. The most complaints were experienced on the right shoulder, waist, upper neck, back, buttocks, hips, left shoulder, and right upper arm. Online motorcycle drivers must pay attention to their nutritional needs, stop smoking, and stretch 1-2 times a day regularly between work hours

Ethical Approval

Ethical approval for the study was granted by the Health Research Etics Committee Faculty of Public Health Universitas Airlangga (Reference Number: 69/EA/KEPK/2022).

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Competing Interests

All the authors declare that there are no conflicts of interest.

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No funds were received for this study.

Underlying Data

Derived data supporting the findings of this study are available from the corresponding author on request.

REFERENCES

1. Panumasvivat J, Surawattanasakul V, Kwangsukstith S, Chollada Mahakkanukrauh, Kiratipaisarl W. The relationship between working conditions, vehicle factors, and work-related musculoskeletal disorders affecting job satisfaction and job stress among motorcycle food delivery riders. International Journal of Hygiene and Environmental Health. 2025;267:114594. http://dx.doi.org/10.1016/j.ijheh.2025.114594
2. Shin DS, Byun JH, Jeong BY. Crashes and Traffic Signal Violations Caused by Commercial Motorcycle Couriers. Safety and Health at Work. 2019;10(2):213–218. http://dx.doi.org/10.1016/j.shaw.2018.10.002
3. Kim EA, Kang SK. Historical review of the List of Occupational Diseases recommended by the International Labour organization (ILO). Annals of Occupational and Environmental Medicine. 2013;25(1):14. http://dx.doi.org/10.1186/2052-4374-25-14
4. Soares CO, Pereira BF, et al. Fatores de prevenção de distúrbios osteomusculares relacionados ao trabalho: revisão narrativa. Revista Brasileira de Medicina do Trabalho. 2019;17(3):415–430. http://dx.doi.org/10.5327/z1679443520190360
5. Charles LE, Ma CC, Burchfiel CM, Dong RG. Vibration and Ergonomic Exposures Associated With Musculoskeletal Disorders of the Shoulder and Neck. Safety and Health at Work. 2018;9(2):125–132. http://dx.doi.org/10.1016/j.shaw.2017.10.003
6. Darvishi E, Ghasemi F, Sadeghi F, Abedi K, Rahmati S, Sadeghzade G. Correction: Risk assessment of the work-

related musculoskeletal disorders based on individual characteristics using path analysis models. BMC Musculoskeletal Disorders. 2022;23(1):1044. http://dx.doi.org/10.1186/s12891-022-06020-2
7. Izumi K, Yamamori K, Katayama K, Kano Y, Tanaka N, Akima H. Intramuscular blood flow and muscle oxygenation of the vastus lateralis response to intermittent incremental muscle contractions. Experimental Physiology. 2024;110(1):106–114. http://dx.doi.org/10.1113/ep091948
8. Kumari P, Sengar MS, Sengar N. A Mini Review on Lactic Acidosis Effect, Cause, Symptoms, Complications, Metabolism, and Pathodology with Its Diagnosis, Treatment, and Preventions. Journal of Chemical Reviews. 2024;6(1):27–38. https://doi.org/10.48309/jcr.2024.407092.1230
9. Niu S. Ergonomics and occupational safety and health: An ILO perspective. Applied Ergonomics. 2010;41(6):744–753. http://dx.doi.org/10.1016/j.apergo.2010.03.004
10. Tavakkol R, Kavi E, Hassanipour S, Rabiei H, Malakoutikhah M. The global prevalence of musculoskeletal disorders among operating room personnel: A systematic review and meta-analysis. Clinical Epidemiology and Global Health. 2020;8(4):1053–1061. http://dx.doi.org/10.1016/j.cegh.2020.03.019
11. Truong LT, Tay R, Nguyen HTT. Relationships between Body Mass Index and Self-Reported Motorcycle Crashes in Vietnam. Sustainability. 2020;12(4):1382. http://dx.doi.org/10.3390/su12041382
12. Lin KH, Sylvano N, Selvanayagam N, Lin KY. Factors associated with work-related musculoskeletal disorders in commercial motorcyclists. Archives of Environmental & Occupational Health. 2024;79(1):23–31. http://dx.doi.org/10.1080/19338244.2024.2342349
13. Nurhafizhah T, Susilowati IH, Maulana A, Habibullah MF. Safety and Fatigue Risk Factors among Online Motorcycle Drivers in Depok City, Indonesia. KnE Life Sciences. 2018;4(5):702. http://dx.doi.org/10.18502/kls.v4i5.2600
14. Abledu JK, Offei EB, Abledu GK. Occupational and Personal Determinants of Musculoskeletal Disorders among Urban Taxi Drivers in Ghana. International Scholarly Research Notices. 2014;2014:1–5. http://dx.doi.org/10.1155/2014/517259
15. Rezaei E, Shahmahmoudi F, Makki F, Salehinejad F, Marzban H, Zangiabadi Z. Musculoskeletal disorders among taxi drivers: a systematic review and meta-analysis. BMC Musculoskeletal Disorders. 2024;25(1):663. http://dx.doi.org/10.1186/s12891-024-07771-w
16. Diatta AER, Wambo C, Ndiaye M. Prévalence et facteurs de risque des troubles musculo-squelettiques dans le secteur informel : cas des conducteurs de moto taxi et de poids lourds. Archives des Maladies Professionnelles et de l'Environnement. 2020;81(5):654. http://dx.doi.org/10.1016/j.admp.2020.03.596
17. Tarwaka, Bakri SHA. Ergonomi untuk Keselamatan, Kesehatan Kerja dan Produktivitas. Surakarta, Indonesia: UNIBA Press, 2016.
18. Russeng SS, Saleh LM, Wahyulianti WN, Palutturi S. The Effect of Age and Workload on Work Posture toward Musculoskeletal Disorders Complain on Loading and Unloading Workers. Open Access Macedonian Journal of Medical Sciences. 2021;9(E):1115–1121. http://dx.doi.org/10.3889/oamjms.2021.7277.
19. Herzog W, Schappacher-Tilp G. Molecular mechanisms of muscle contraction: A historical perspective. Journal of Biomechanics. 2023;155:111659. http://dx.doi.org/10.1016/j.jbiomech.2023.111659.
20. Gatchel RJ, Schultz IZ. Handbook of occupational health and wellness. Heidelberg, Germany: Springer, 2012.
21. Alfira Safitri Adil. The Effect of Work Posture and Body Mass Index on Work Productivity through Musculoskeletal Disorders Complaints in Operators. Journal of Information Systems Engineering and Management. 2025;10(37s):589–602. http://dx.doi.org/10.52783/jisem.v10i37s.6496.
22. Rahmawati U. Faktor-Faktor yang Berhubungan dengan Keluhan Muskuloskeletal Disorders Pekerja Pengangkut Barang di Pasar Panorama Kota Bengkulu. Jurnal Kesehatan Lingkungan: Jurnal dan Aplikasi Teknik Kesehatan Lingkungan. 2020;17(1):49–56. http://dx.doi.org/10.31964/jkl.v17i1.225.
23. Viester L, Verhagen EA, Hengel KMO, Koppes LL, van der Beek AJ, Bongers PM. The relation between body mass index and musculoskeletal symptoms in the working population. BMC Musculoskeletal Disorders. 2013;14(1):238. http://dx.doi.org/10.1186/1471-2474-14-238
24. Hanif A. Hubungan Antara Umur Dan Kebiasaan Merokok Dengan Keluhan Musculoskeletal Disorders (Msds) Pada Pekerja Angkat Angkut UD Maju Makmur Kota Surabaya. Medical Technology and Public Health Journal. 2020;4(1):7–15. http://dx.doi.org/10.33086/mtphj.v4i1.715
25. Bhatia V, Vaishya RO, Jain A, Grover V, Arora S, Das G, et al. Identification of prevalence of musculoskeletal disorders and various risk factors in dentists. Heliyon. 2024;10(1):e23780. http://dx.doi.org/10.1016/j.heliyon.2023.e23780
26. Heidari M, Ghodusi Borujeni M, Rezaei P, et al. Work-Related Musculoskeletal Disorders and Their Associated Factors in Nurses: A Cross-Sectional Study in Iran. Malaysian Journal of Medical Sciences. 2019;26(2):122–130. http://dx.doi.org/10.21315/mjms2019.26.2.13
27. Shintia Yunita Arini, Dani Nasirul Haqi. Risk Analysis of Musculoskeletal Disorders (MSDs) Complaints on Batik Crafters Under The Assistance of Ademos Indonesia. Indian Journal of Forensic Medicine & Toxicology. 2021;15(2):3471–3477. http://dx.doi.org/10.37506/ijfmt.v15i2.14911
28. Ramadhan P, Purwaningsih R, Budiawan W, Kurniawan MSD, Prakosa NGA. A TRIZ approach to motorcycle passenger comfort in developing an ergonomic Backrest. World Journal of Advanced Research and Reviews. 2025;26(3):1015–29. http://dx.doi.org/10.30574/wjarr.2025.26.3.2250
29. Wójcik R, Trybulec B. Occurrence and Intensity of Spinal Pain in Motorcyclists Depending on Motorcycle Type. Central European Journal of Sport Sciences and Medicine.

2017;20:81–91. http://dx.doi.org/10.18276/cej.2017.4-09
30. Andriani I, Sumardiyono, Murti B. Correlations between Physical Activity, Work Duration, and Stress on the Risk of Musculoskeletal Disorders in Online Motorcycle Drivers in Surakarta. Journal of Epidemiology and Public Health. 2024;9(1):92–105. http://dx.doi.org/10.26911/jepublichealth.2024.09.01.09
31. Suherdin, Muhammad Fajri Fadhila, Ratna Dian Kurniawati. Risk factors for subjective complaints of Low Back Pain (LBP) in District X Office Workers Bandung City, Indonesia. World Journal of Advanced Research and Reviews. 2023;19(2):1467–1473. http://dx.doi.org/10.30574/wjarr.2023.19.2.1756
32. Caruso CC. Negative Impacts of Shiftwork and Long Work Hours. Rehabilitation Nursing. 2014;39(1):16–25. http://dx.doi.org/10.1002/rnj.107