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IMPACT OF PUBLIC TRANSPORT USE ON MUSCULOSKELETAL HEALTH AMONG PHYSIOTHERAPY STUDENTS IN KARACHI: A CROSS-SECTIONAL STUDY

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Abstract

Background:
Musculoskeletal disorders (MSDs) are increasingly recognized as a public health concern associated with prolonged sitting, vibration exposure, and poor posture during daily commuting. In Karachi, physiotherapy students frequently depend on public transport where overcrowding, uneven road conditions, and sustained static posture exacerbate the condition.

Objective:
To evaluate the effect of regular public transport use on different body regions among physiotherapy students using the Extended Nordic Musculoskeletal Questionnaire.

Methodology:
The research was done among 322 students of physiotherapy who were commuting using the public transport. The Open Epi was used to calculate the sample size. The data were gathered by using the extended version of the Nordic Musculoskeletal Questionnaire and self-administered commuting survey. The SPSS version 27.0 was used to conduct the statistical analysis. The assistance of Chi-square test and Spearman correlation was used to identify the prevalence and assess the associations.

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Results:

A total of 322 physiotherapy students who regularly used public transport participated in the study. The mean age was 21.9 ± 1.62 years. The sample consisted of 298 (92.5%) women and 24 (7.5%) men. Results indicated a high prevalence of MSDs with 72.7% of participants reporting lower back pain and 72.4 % reporting neck pain, followed by discomfort in the shoulders, upper back, and lower limbs. These findings indicate that axial and postural regions are most affected, likely due to prolonged sitting, non-ergonomic seating, and continuous vibration during commuting.

Experiencing issues during public transport use showed statistically significant positive correlations with the upper back ($r = 0.192$, $p < 0.01$), lower back ($r = 0.175$, $p < 0.01$), wrist ($r = 0.173$, $p < 0.01$), shoulder ($r = 0.141$, $p < 0.05$), and knee ($r = 0.125$, $p < 0.05$).

Conclusion:

Among young physiotherapy students who use public transportation, the prevalence of MSD is particularly high in the axial and postural areas. These results highlight the necessity of ergonomic understanding and safer commuting environments to minimize musculoskeletal stress.

NTRODUCTION

1. BACKGROUND OF THE STUDY

Public transportation is a transport system that involves all the common instances of transport that can be traveled without the use of individual cars. This is in form of taxis, minibuses and buses which offer convenient means of movement. Public transport is very important to the passengers because they enable smooth passage between one location and the other. The developed public transport system can be used as a solution to the issue of urban mobility through decreasing congestion levels, reducing pollution, and improving accessibility, which have been the case across the developed nations. It has several applications that can make people live a better life because safe, efficient, and affordable transportation services can be provided. (1, 2)

A decent transport network properly manages and makes proper use of the urban habitat besides making transportation accessible and affordable so that an individual can easily access their place of work, learning centers, social events, recreational areas, and economic centers. Public transportation influences the travel at individual levels significantly and the degree to which people use or own personal vehicles (3). Rapidly urbanizing cities have to create sustainable transport systems that would take care of the travel needs of all the economic classes (4). With the help of this, every day, economic groups tend to travel to different places, and they do so in search of education, jobs, purchases, and other purposes. Transportation which is used by people plays a major role in the economy of the nation in the sense that it offers employment, enables investment and decreased fuel importation and it shields the environment from the global warming since it reduces road jam and can aid the passengers to get to where they want them easily. (5)

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Even increasing the public transport will help to increase travel efficiency and settle down to sustainable commuting. Nevertheless, effective services in the sphere of public transport presuppose active operations of the government, policy development, governmental financing, and collaboration among the authorities, transport employees, and millions of people who use the systems daily. (6)

Urban transportation requires the ability to get to the end destination without a lot of strain and that is why the lack of efficiency of transport and low quality of service ultimately leads to musculoskeletal discomfort, which directly impacts the health of the passengers (7). Overcrowded passengers, especially those who are overcrowded, stand awkwardly that increases their susceptibility to MSDs. The overcrowded buses also force standing passengers to climb the overhead rails, and that is the cause of upper back, wrists, and shoulder soreness and pain specifically. (8) So, users of public transport (PT) are frequently exposed to poor infrastructure, congestion, and delays. These inefficiencies result into excessive commute time, which contributes to stress and other health related issues, especially, musculoskeletal disorders (MSDs). (9)

Musculoskeletal disorders (MSDs) have now emerged to be a matter of concern and whether occupational or non-occupational because of repetitive movements, awkward positions, strains of exerting too much force, exposure to vibrations over a long period of time. These are disorders affecting mainly the muscles, tendons, joints and nerves, which cause a prolonged pain, stiffness, swelling and decrease in mobility and livelihood and productivity of an individual. The musculoskeletal disorders (MSDs) have been established in numerous groups and the ones established include truck, taxi, and bus drivers (10). The passengers of the public transport are poorly examined. Among the risk factors that could cause the development of MSDs, one may single out age, gender, poor postures, long vibrations, and poor working conditions that impact both passengers and drivers in the whole world. (8)

Frequently, the users of the public transport (PT) which include buses, rickshaws, vans, etc., are exposed to stressful factors, which include road conditions (poor roads, potholes and uneven borders), as well as traffic jams, all of which create repetitive stress on the musculoskeletal system, to which the shoulders, neck, back, and the lower limbs (in particular) are subjected (11).The poor conditions of the roads exacerbate the problem, including potholes. The continued experience of such situations leads to gradual damage to the musculoskeletal system that results in the incessant pain and suffering that influence the day-to-day lives and productivity of a person. (8)

The public transport is a critical means of transport especially in the cities where most of the people use it in their commuting. Nevertheless, musculoskeletal discomfort can be caused by malfunctioning situations of the types of trains and buses. The urban transport system in such cities as Karachi is inadequate to meet the demand of travelers, is not well developed, and is not managed properly, which makes it slow and crowded and causes numerous inconveniences to the clients that use it on a regular basis. The lack of good facilities of public transport, poor roads, and traffic jams will result in people being late to the destinations causing them to experience stress, low productivity, and missed work or academic appointments. The other aspect is that unlike the private car, the

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public buses and vans cannot accommodate people with other body type like taller, shorter, obese, and people with a disability. Consequently, the passengers usually need to squeeze into tight areas, which puts an additional strain on their spine, shoulders, and joints, and raises the chances of musculoskeletal injury. (8)

Gender is the other important role in the prevalence of MSDs among the users of the public transport. It has been demonstrated that women are heavy users of public transport as opposed to men and this exposes them to risk factors that cause MSD. Studies so far carried out have established that men tend to use cars or bikes as a mode of transport whereas women use buses and engage in a ride in cars. This means that a sizeable percentage of people who use public transport are women, which means that they cannot be overlooked in regard to exposure to the risk factors. Generally, the concept of travel safety presupposes that passengers feel safe when using the services of transport means or stay at terminals and bus stops and are not under the threat of harm or recoil. (12) Safety worries have consequences on the capability of women to travel and be transported to locations on a daily basis, and limit their access to medical care, education and work, which causes extended social impacts. (13)

The safety problems of women and gender-diverse individuals are essential to be addressed in order to sustain the gender equality beyond ensuring inclusive and sustainable urban development. Numerous steps in response to the necessity to make women transportation safer have been made, both at the level of real infrastructural changes and in the framework of changes in policies. In keeping with a general conceptualization of the problem, such measures respond to safety concerns pointed out by various pieces of research. It is a significant issue that one cannot ignore because majority of the commuters are women and their safety is a critical aspect that is considered in preference of the public transport to other vehicles. (14)

Crowding, inadequate seating and protracted standing result in musculoskeletal pains among female commuters who travel regularly using the public transport. In addition, the ergonomic requirements of the female riders to which the construction of the public transportation systems is frequently not given due attention deteriorate the situation by promoting the risk of musculoskeletal diseases and leaving the professional more inclined to experiencing muscle soreness and fatigue, which is disruptive to their activity of everyday living. (15)

The extent of satisfaction and utilization of the passenger is highly contingent on their frequency of the service, travel time, safety, punctuality, cost, comfort, and hygiene. These factors may have direct effect on the physical and emotional stress of commuting because individuals tend to use it more often which leaves them more likely to experience the musculoskeletal pain. The choice of passenger to use public means of transport versus the likes of the private transportation is subject to many factors which include the frequency of service offered, time taken to travel, reliability of the service, and comfort. There are also situations that make the population oriented to use public transport, such as an individual schedule, material resources and availability of such means of transportation. In the illustration, students are subjected to prolonged sitting or standing, carrying heavy backpacks in their shoulders, walking distances or even those perceived to be uncomfortable on their way to

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institute just because the way is too small to be accommodative, and all these may lead to musculoskeletal pain in the long run (16).

Musculoskeletal pain is commonly associated with prolonged sitting, obesity, old age, physical inactivity or heart diseases that influence the life expectancy. The MSDs such as neck discomfort, shoulder pain, low back pain, and knee discomfort are some of the leading causes of disability in the world based on the number of years of disability since they affect the overall productivity of the individual and change the way the person is viewed by the people who use the transport service (5). The lack of seats often leaves the guests with no choice but to stand long hours after they are indoors due to lack of enough seats. Failure to drive in a careful manner, abrupt halts, and extended duration of suffering vibrations due to the vehicle-road interface are all causes of the aggravating pain. The example is that students sit or stand all day, carry heavy backpacks on their shoulders, they walk long ways, or have their bodies in uncomfortable positions during traveling because of the limited space, so all these potentially lead to a musculoskeletal pain in the long term. (16)

Individuals using mass transit systems are extremely disadvantaged as they have poor posture, time constraints, too much sitting, vibration attributed to the vehicle-road interface, excessive physical activity and twisting motions that can be detrimental to their health, as well as having to contend with the uneasy circumstances of the road. To eliminate MSDs among users of the public transportation, a multimodal approach putting a great emphasis on the scheduling mechanism, the enhancement of road conditions, the improvement of transportation infrastructure, and the education of ergonomic practices are required. (17) Public transportation is necessary when it concerns the increase of mobility and the quality of life. Nevertheless, the low quality of services may impact negatively on the wellbeing and health of consumers. Given the prevalence of living in places such as Karachi that have a high use of public transport, there should be a priority to treat the musculoskeletal health conditions of the passengers. Much attention has not been paid to the users of public transportation, which are also exposed to such factors as biomechanics and environment, unlike the vast research on MSDs among professional drivers. The prevalence of MSDs and making commuter experience more comfortable may be reduced through improving public transportation and raising awareness about musculoskeletal health. (11)

Transport systems are crucial in urban cities because they offer the safest and cheap means of traveling to individuals and a greater growth cannot be realized unless traveling and mobility issues are addressed because majority of the populace relies on the use of public transport as the mode of transportation. There are accessible methods of transport via which people live in diverse groups, and it contributes significantly to the country economy (2). Therefore, it has become extremely significant that proper and expansive bus networks should be developed to be able to comfortably carry huge number of commuters comfortably. (18)

The following is the importance of studying the competitiveness of public transportation system since it offers mobility to various occupational units such as schools, healthcare facilities and workplaces and also provides vulnerable groups such as students and older adults with options on getting to their destinations. It also does not affect the environmental goals as it reduces air pollution

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because of the reduction in the diesel fuel. In general, transport policy objectives are achieved whereby, an increased number of individuals will opt to use public transport as opposed to owning a vehicle given the advantages attached to it. (19)

Cities throughout the world are experiencing the dangerous facet of active driving and are thus aiming to shift to a more sustainable urban transport network that emphasis on public transportation to neutralize the damaging impact particularly of the gases emitted by the cars to save the surrounding (20). Although the commuting by bus or train constitutes a great portion of the day, we do not know much about the impact that it has on the well-being of individuals who use transport on a regular basis. (21)

Traffic jam is an escalating international problem, but very detrimental in developing world countries like Afghanistan, whose outcomes are much devastating because of lack of resources and inadequate infrastructure. Traffic congestion was also a major issue that affected Kabul, the capital city and the adjacent regions, and the problem was caused by a number of related factors. The lack of adequate urban infrastructure, bad traffic control, crass roads and erroneous road user attitude enhances the issue already, and a high population density and quick population growth strain the road system alike. The outcomes have long-term consequences on social life, environment, and the economy, and also lead to hazardous amounts of air pollution that are directly linked to the physical and mental wellbeing. Not only can congestion be the cause of delays and decreased productivity but also worse living conditions due to the added stress, noise, and harmful gases that also can pose threats to the well-being of humans (22)The solution to this problem lies in the broad and immediate interventions like increasing and developing transport systems, enforcing laws, escalating the number of public buses, building the buses and roads properly, enhancing the performance of the traffic control, and integration of electronic systems to enhance better traffic management so that the passengers might not be exposed to the hazards. (23)

The application of alternative means of transport may affect safety and environment. Studies indicate that private vehicles have more accidents and injuries as compared to public transport. Moreover, cars that use petrol and diesel engines have more noise and carbon emissions than other public transport and active transport systems such as walking or cycling that will have a significant role to play in ensuring that the environment is not subjected to global warming. (24) One of the biggest threats to humanity and environment that the future transport offers are the global warming reduction (25). Moreover, the use of public transport is a healthier alternative to using personal automobiles. In certain cities, buses and rail networks are well developed and linked with others whereas in others, the networks are underdeveloped. The Big data analytics are used to analyze traffic patterns to enhance value through increased operational efficiency and policy formulation to reduce traffic and to minimize the issues and congestion experienced by commuters to the work place (26). A good example of a community-based school transportation that is largely implemented in a number of countries to deliver children in their neighborhoods to school can be used to explain its significance. Such an option is cheaper and cost-effective compared to having a personal car and helps the working parents, especially those who cannot take their children to school themselves.

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Vans have gained immense popularity as a mode of transport in Bangladesh, with most of the citizens belonging to low-and-middle income families and unable to afford their own vehicles or buses to school. Significant benefits that were highlighted by parents included saving of both time and money, support of multiple locations, and working parenthood. However, there are also major issues on the other hand that involve long routes, bad design of the vans, inconsistent schedules, congestion-related inconveniences and hazards that come along with irresponsible driving that may endanger the health of the student. (27)

The current trend in transportation planning is now concerned with the ease of daily movement of the people as well as the enhancement of the transportation system status, after the initiative of alleviating the negative impact of transportation on climate, the environment and health of the population. A sustainable transportation system can be defined as the system that can satisfy the mobility demands and the expectations of the current population and reduce the adverse environmental impact as well as retain the potential of future generations to fulfill their demands in terms of mobility and transporting to communal means of transport effectively. (28)

Modern and efficient public transportation networks have short waiting periods, high travelling speed, punctuality, accessible passenger information, simple and consolidated ticket sales, comfortable transportation and easy boarding that reduces the waiting time of passengers and enable them to reach their destinations on time. The possibilities of increased transit access in increasing the participation level and reducing social exclusion are frequently neglected in existing transport planning and evaluation proposals (29). Due to this exclusion, the social equity benefits of transit investments would remain underestimated, and this it might result in the marginalization of the clients. (30)

Most of the studies advise on improvements without taking into consideration the viability of the approaches in the real-world setting and their applicability to decision makers and planners. Moreover, the strategies to plan often tend to focus on addressing the mobility requirement of the disadvantaged groups, but in isolation and not fully incorporating them in the scheme of the large ones. This leads to a lack of relationship between theory in academic study and practice reality and constraints that transport providers have to operate, which forms a theory practice gap. It also raises the risk of inadequate access and services that may be offered, particularly to at risk groups and of failure to achieve sustainability of accessibility in case these shortcomings are not addressed. (31)

The most prevalent work conditions of the workplace behaviors include work-related musculoskeletal illnesses (WMSDs) that are painful. They would cause significant morbidity among many working populations leading to reduced productivity, diminished quality of life as well as high health care and compensation costs.(32) Research has also been conducted to date on WRMSDs with 80 percent of bus drivers, 81 percent of truck drivers and 71 percent of taxi drivers being affected. Road accidents are the main causes of death and injury on the world scale which has significant implication in terms of both the family and the economy of the country. Studies have established that Job strain has been attributed to cardiovascular and musculoskeletal issues, fatigue and bad habits. (33)

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By introducing appropriate seat design, which is the single solution that presents an opportunity to reduce the number of compensable cases of low-back pain by a third, the ergonomic treatment can significantly decrease the injury rate. Most of the body weight is supported by the ischial tuberosities and the soft tissues surrounding the ischial tuberosities leads to the provision of the needed support during sitting which depends on the design of the seat, the work requirements and personal practices since the bus drivers are highly likely to be affected by musculoskeletal discomfort. Research have confirmed that the burnout rate among drivers is quite high, with the majority reporting high or severe burnout rates in their personal lives, in their work experiences as well as with their clients. Musculoskeletal pain was also common especially in the back and neck regions among drivers. (34)

Based on the extent of exposure, it is important to follow extensive prevention and control measures in a bid to lead a healthy lifestyle. They should comprise of special training systems, routine ergonomic centers, availability of healthcare, and must have efficient rehabilitation programs to aid in preventing and limiting the development of MSDs in bus drivers. In addition, MSK pain is deemed as the most specific type of health concern and a measure of poor health concern that has significant implications on the workforce, comprising of discomfort and low quality of life. Along with it, MSK discomfort may lead to nonappearance, reduced performance, and increased health care costs.(9, 35)

The recent researches indicate that approximately 10 percent of the entire workforce presents the health issues that are directly linked to their work. It is also confirmed that the knees are more affected because all the force exerted on the lower limb occurs mainly on the knee articulation hence it is more affected. Further on, conditions of the musculoskeletal disorder are divided into three types: those being mild, moderate, and severe; and most disorders present repeatedly. The phenomenon of burnout related to travelling is connected to the phenomenon in stages. First, personal experience feels uneasy and weary of the working conditions and performance of the work but such feelings do not affect individual performance driven by stagnation stage where demands of the work may cause decay of performance and stimulation. Secondly, it is followed by irritation phase where sustained stress gradually causes an individual to lose patience and work motivation causing a constraint on the individual performance. Finally, the difficulties appear to perform the task because of discomfort and the individual, who has to encounter these needs, needs help and intervention because of insufficient bodily and psychological conditions (36, 37).

Also, according to WHO 1.7 billion approx., personal suffer musculoskeletal disorders in the world wherein, back pain exhibits the most prevalent effect as opposed to other MSK ailments. In the same vein, one third of all observed incidences of absence and sick leaves in the healthcare workforce can be attributed to MSDs (37). MSDs affects all occupational divisions, including healthcare employees, businessmen, and commuters, and this kind of worker is particularly vulnerable since they have a greater and prolonged exposure to risk factors that cause MSDs, including vibration, posture and repetitive movements (11).

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One of the probable causes of MSK pain highlighted in previous studies include localized fatigue of the erector spine muscle, insufficient physical activities, too much time of non-ergonomic sitting and poor ergonomic and psychological factors (11, 38).

Developed transport systems are important in urban cities because they facilitate safe and cheap travel to the people and without resolving the issues of travel and movement, higher growth cannot be realized because most citizens rely on transport systems as the primary mode of transport. (2) Several works have been done so far on prevalence of MSDs in users of the public transport but there is extremely scarce data on its prevalence in young students. Our study will fill this gap by determining the prevalence of MSDs among younger student commuters and helping to alter the given circumstances towards a healthier one. This study will attempt to educate policy makers, transport authorities and learning institutions on the necessity to make immediate ergonomic changes to transport systems by emphasizing on the risk factors that lead to their problem.

2. STATEMENT OF THE PROBLEM

Contemporary city life has precipitated the drastic change in sedentary habits and the extended sitting duration not only in the school environment but also during the commuter activities in day-to-day life, which makes the world susceptible to musculoskeletal disorders (2). In cities like Karachi, where most citizens live in metropolitan areas, young adults, this is in the case of Karachi, students are known to be constantly exposed to a blend of both physical and environmental stressors such as overcrowding on the roads, poor seating ergonomics, poor road patterns, and long commuting times (1, 7, 8). The effects of these repeated exposures are cumulative on the musculoskeletal system which is in most cases experienced in the cervical, lumbar, and shoulder areas causing discomfort, pains and eventual disabilities. (11)

In spite of MSDs being studied widely within the context of occupational group, including commercial drivers, factory workers, and office employees, this issue is a somewhat unexplored territory of research among young population. (39) The stereotype of the supposed age limitation of MSDs as manifested in old age and physically demanding jobs has been used to underestimate the risks faced by students. (40) The group of physiotherapy students is especially paradoxical because they are supposedly well informed on ergonomics, and know how to act in the most preventive way, yet due to their academic and clinical responsibilities, as well as to their long-lasting commuting due to poor conditions, they become exposed to non-optimal biomechanical strain. This paradox is not only a challenge to the professional self-protection assumptions but also an indication of the neglected aspect of students within the healthcare field as well.

The issue is even more critical in the realities of Karachi socio-infrastructure which imposes scarce means of transportation, unpredictable hermits of travelling, and miserable ergonomics of vehicles all combine to increase the risk of posture on strain. (1, 7) The biomechanical principles have not been considered in most of the public transport vehicles and these vehicles lack the necessary support in the back, space to move or control vibrations. Such conditions may be experienced on a daily basis with usually several hours in duration contributing to a state of chronic muscular tension and

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the malalignment of the spinal regions and microtrauma. (35, 36) Physiotherapy students because the students have tight schedules coupled with clinical workloads do not engage in proper recovery or preventive exercises, thus predisposing them more to early-onset MSDs that can affect their performance in relation to academics as well as work functionality.

In spite of these facts, empirical data that studies the direct correlation between musculoskeletal disorders prevalence and the utilization of the transport is severely lacking among the physiotherapy students in Karachi. (1) The lack of local data restricts the ability to develop specific ergonomic interventions, awareness, and prevention physiotherapy programs in accordance with the student population. Furthermore, the current health and transport policies do not incorporate planning strategies with musculoskeletal in place on a regular basis. (19, 31) In the absence of this evidence-based knowledge, the onslaught of MSDs in young adults will persist with little notice because it will negatively impact the physical health of the new healthcare worker.

Moreover, less is known about the impact of contextual and behavioral variables that include commuting time, posture changes, lugging, and the frequency of travels in this population. There is exposure to sustained vibration, limited mobility, and unequal loading of many students on a daily basis, which eventually can cause a change of muscular balance and posture position among the students. (16, 41) These low-level but chronic stressing factors lead to impairment of functions which in addition to personal health may also diminish clinical effectiveness and manual skill-set, both critical to career long-lasting of a physiotherapist. This invisible societal health problem is further escalated by the absence of preventive ergonomics in the structure of international transport systems and weak institutional awareness.

Thus, the proposed research aims to explore the prevalence, distribution patterns as well as the factors that contribute to the occurrence of musculoskeletal disorders in Karachi-based physiotherapy students using a public transport mode. It is through bridging this critical gap that the research will produce region-based evidence that can be used to inform the education reforms, provide an ergonomic awareness intervention, and generate an intervention at the policy level. Finally, it tries to enhance sustainable musculoskeletal wellbeing and musculoskeletal functional longevity occurrences amid physiotherapy scholars the very ones who will spearhead any future plans in physical rehabilitation and preventive healthcare.

3. RATIONALE/JUSTIFICATION

In the modern-day busy city, mass transport has turned out to be an essential part of everyday life especially to students and the young adults who use it to reach institutions of learning, places of employment and workplaces, as well as clinical placements. Public transport has been the main source of urban mobility in densely populated metropolitan cities such as Karachi where a great number of people in the population travel through cheap and convenient public transport. But such reliance on common means of conveyance tends to be unhealthy to the human body. Commuters get consistently subjected to situations that are hardly ergonomically correct overcrowded vehicles, inadequately maintained road infrastructure, irregular or not comfortable positioning, abrupt

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deceleration, long durations of sitting, and incessant vibrations in the vehicles. All these collectively cause long-term mechanical stress to the body particularly on vulnerable areas like the neck, shoulders and lower back, hence making them predisposed to musculoskeletal pain and discomfort. (7, 8)

The problem is even greater when one looks at the younger demographic, especially among student who is an incredibly vibrant and active group in the academic sphere that forms a part of the society. Though they are still in the prime of their physical appearance, young adults are not exempt of the effects of cumulative lack of exercise, poor body positioning and strain. In this specific case, physiotherapy students are especially positioned. Even when they hold academic information on the issue of anatomy, posture, biomechanics, and musculoskeletal health, they do not regularly apply their theoretical knowledge to self-care. The nature of their academic and clinical training, including prolonged study time, direct work with patients, and physical displays, coupled with commuting to the workplace day-to-day stresses, leads to an irony of people who are supposed to prevent and treat musculoskeletal disorders being in high risk. (11)

The situation in Karachi is further worsened by lack of transport infrastructure, erratic traffic jams, absence of ergonomic infrastructure, and ignorance by the population of the issue of posture and mobility. The users of the public transport are usually prone to spend considerable time traveling in a compressed or awkward stance, keeping minimal possibilities of varying their posture or even of resting. According to time-lapse, such recurring exposures may result in short-term pain, as well as in long-term musculoskeletal disorders (MSDs), exhaustion, and impaired functional performance. Since the future employees of any healthcare organization are physiotherapy students, the existence of such problems at this early level of education may not only have an impact on their personal health but also on their future success at work and in practice. (36)

This issue is relevant to the society and timely since the urbanization and development of the current educational systems in Pakistan have caused a consistent increase in student mobility. Though the health effects of long commuting and bad ergonomics have been recognized on the international scene, there is lack of research in the local area to comprehend the effect of these causes on the musculoskeletal wellbeing of young adults. The available literature has been dominated by occupation drivers, industrial workers, and office employees, and there is a significant gap in the literature about students and other non-occupational groups of commuters. This relationship is, thus, critical in the design of contextually-sensitive preventive strategies and awareness programs that are respectful of the needs of such a population.

The urgency of the study is therefore justified by the necessity to define locally sensitive evidence on musculoskeletal implications of the use of public transport to its users among the physiotherapy students of Karachi. The research will address the knowledge gap that is needed in the area of occupational ergonomics and health by establishing the prevalence, distribution, and risk factors of transport-related musculoskeletal symptoms among students. The results can be utilized in the formulation of the ergonomic concepts, the formulation of awareness on how to be in the right position during travelling, and the inculcation of the concept of musculoskeletal complication

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prevention in the learning environments. The study will eventually lead to the improvement of commuting patterns, the general health status of the urban students and would be a subset of the overall objectives of sustainable urban health planning in the new urban centers such as Karachi where the dependency on the local means of transport is gradually increasing.

In addition to the direct health effect, the consequences of this issue may be much deeper, both in terms of education and career. The fact that MSDs do not only exist in the physiotherapy students, but they also affect their physical state negatively, but their learning abilities, fine motor skills and performance in the clinical setting. Unremitted pain or discomfort may disrupt the concentration, decrease stamina during actual session and performance of therapizing chores. This could lead to burnout, absenteeism or even early burnout of the career- the things that could eventually lower the quality of service provided to the patients by the future medical practitioners. The problem of musculoskeletal health care during the first years of studying physiotherapy is, thus, not only the question of personal well-being but also the question of professional responsibility.

In addition, the problem is an expression of greater structural and sociocultural realities that dictate the health behavior in urban Pakistan. A large proportion of students believe that this amount of discomfort, pain or fatigue is a part of everyday commuting and normalization, and not the sign that biomechanical errors are occurring. This kind of negligence is maintained by the non-existence of the awareness programs, institutional ergonomics programs and preventive physical health programs in schools. (35). This difference makes it possible to conclude that there is the necessity to possess multidisciplinary response, which will consist of health education, transport policy and ergonomic reform. The physiotherapy programs specifically, have the ethical obligation of inculcating into the physiotherapy students, self-care, strength and practical ergonomic consciousness within the background of healthy maturation of a professional.

There are also more general implications of the research to the urban sustainability and preventive healthcare planning in the public health perspective. The Karachi transport system is overstretched, and the physical/environmental stressors are being subjected to the daily commuters particularly the students because of the growing urbanization of this city. The risk factors of transport can be identified using empirical studies and the results can be utilized to carry out certain interventions, which may involve improving the bus designs, designing seats with the right postural functionality, technology to eliminate the effects of vibration and educating student commuters. Furthermore, the musculoskeletal health as the aspect of the higher urban planning can meet the purpose of developing healthier and more energetic segments of the population that may be productive in the long-term either in the academic or in the working sphere.

Lastly, the research is in line with the international trend of community-based and preventive health care. It helps to identify the risk factors early and the establishment of the ergonomic awareness, thereby, enhancing the active health promotion and not the reactive treatment. The results should be feasible to the educators, health practitioners and policy makers who would wish to foster musculoskeletal health resilience of the young adults. By so doing, the research brings out a bigger

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picture where, not only is the protection of physical health of future physiotherapist an investment in personal health but also an effective, caring and physically fit healthcare system.

4. RESEARCH QUESTIONS

1. What is the prevalence of MSDs in physiotherapy students who use the Karachi public transportation?
2. Which are the most impacted body parts of such populations on MSDs?
3. Which sociodemographic (age, gender, occupation) and commuting-related (duration of commute, posture, frequency of commuting) variables are associated with MSDs in these groups?

5. OBJECTIVES OF THE STUDY

- To identify the impact of the regular usage of a public transport on the different body parts of the physiotherapy students using the extended version of Nordic Musculoskeletal Questionnaire.
- To identify the commuting-related variables (length of travel, mode of transportation, sitting position and frequency of use) that are associated with musculoskeletal pain.
- To make recommendations and suggestions on the preventive measures such as taking frequent breaks, good posture and stretching exercises to alleviate the musculoskeletal load among the users of the public transport.

6. HYPOTHESIS

Null Hypothesis (H_0): The incidence of musculoskeletal disorders and the use of public transport among physiotherapy students in Karachi are not significantly related.

Alternative Hypothesis (H_1): There is a significant relationship between the use of public transport and musculoskeletal disorders among the physiotherapy students in Karachi.

7. OPERATIONAL DEFINITIONS

Musculoskeletal (MSK) Pain:

The MSK pain is defined as pain, discomfort, or soreness, which is in the muscles, bones, joints, ligaments, or tendons and may be a consequence of repetitive strain, poor posture, or sitting as in the case of the users of the public transport.

Public Transport:

The term public transport is used to refer to the common passenger transport that may be utilized by the people like buses, rickshaws and taxis which operate in an urban or suburban setting such as Karachi.

The Nordic Musculoskeletal questionnaire:

Nordic Musculoskeletal Questionnaire (NMQ) is a standardized tool that is employed in the measurement of musculoskeletal pain and discomfort in various body parts over a given period.

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Physiotherapy Students:

The population of interest was supposed to be the undergraduate physiotherapy students of the well-known institutions in Karachi. These individuals were selected because they were familiar with the body mechanics professional knowledge and their experience of the physical requirements of communing to the city.

Duration of Commute:

The time taken in the commuting between the two was calculated as the time taken in commuting between home and the educational institution on a normal day. The commuting time that was more than one hour per way was identified to be prolonged commuting.

Work Musculoskeletal Muscle Disorders (WMSDs):

The musculoskeletal disorders of the work in this study are pain, discomfort, or functional impairment of the muscles, tendons, joints, ligaments, or other soft tissues which are the effects of repeated physical activity, awkward posture, sustained load, or biomechanical stress with respect to the academic and clinical activities of physiotherapy students. The disorders are work related since they are influenced by the long sitting during commuting, long hours of studying, clinical practice and manual handling during the physiotherapy training.

LITERATURE REVIEW

1. THEORETICAL BACKGROUND

The research is founded on the ergonomics and biomechanics theories that are underpinned by the biopsychosocial health model in elucidating the contribution of the environmental and behavioral factors to the occurrence of musculoskeletal disorders (MSDs) among the physiotherapy students and users of the public transport. All these theoretical models will give the complete picture of the correlation between the physical posture, mechanical loads and environmental stressors and the personal health outcomes. It is based on this that the research provides an analytical basis that contextualizes musculoskeletal health in the context of human movement, environmental ergonomics and human psyche i.e. the Karachi transport situation and the necessity of physiotherapy education.

Biomechanically speaking, the human musculoskeletal system is a dynamic system which has a balancing system, a movement system, and an adaptational system. It works by the intricate system of levers, forces, and load-carrying tissues which depend on a constant movement as a source of nutrition and stabilization. Nevertheless, increase in the rigidity of movement, such as is experienced during sitting over a long period or during whole body vibrations is sufficient to destabilize the balance between mechanical loading and tissue recovery. Long positions further intensify the intradiscal pressure, change the spinal curvature, and in the postural stabilizing muscles, which include the erector spinae, trapezius, and multifidus, cause muscle fatigue. Uncompensated

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repetitive micro-strains lead to tissue degeneration, discomfort and chronical musculoskeletal pain. Approaching the concept of the development of public transportation, the passengers are exposed to the sustained seated postures that lack proper support, many jolts, jerks, and vibration in the form of the vehicle sitting and road bedrock. Sudden acceleration, braking and poor suspensions are the biomechanical stressors, which combine to create cyclic loading on the spinal and lower limb structure. This results in the musculoskeletal tissues being overused and becomes dysfunctional due to surpassing their physiological limit of endurance to the task which is biomechanical strain.

The biomechanical model as well insists on the cumulative effect of the low forces though time especially on people with commuting daily tasks. Although individual exposures may be considered insignificant, their repetitive character is what leads to the eventual wearing-out and tear of the musculoskeletal tissues. It usually happens in the cervix and lumbar where flexion-extension movements as well as the exposure to vibration hastens the dehydration of the disc and the stress of ligament. The students of physiotherapy spend much time in lectures and clinical rotations; therefore, they might already have decreased postural variability and muscular stiffness prior to commuting. Therefore, their susceptibility to MSDs is magnified by an extra stressful situation encountered during the public transportation. Such a theoretical relation highlights the importance of considering transport-related strain as a kind of continuation of everyday biomechanical load, which combines with academic and clinical tasks.

The ergonomic theory supplements the biomechanical explanation by relocating the emphasis on the human body to the organization of the area, in which people are working under. Ergonomics depends on the basic assumption that safety, comfort, and efficiency of the systems and tools should optimized the relationship between the environmental demands and the capabilities of human beings. Considering the city of Karachi as an example of the transport systems, it is clear to have a mismatch of the size of the human body and the design of the vehicles. Lots of buses and vans do not have a suitable seat depth, lumbar curve or variable height, which means that commuters have to sit in unnatural postures that put additional mechanical stress. In addition, limited legroom, the hardness of seat surfaces, and an occurrence of lack of vibration absorbing systems enhance the physical discomfort and fatigue. The constant exposure to these poorly conditioned situations, folding and jostling and limited mobility cause compensatory muscle activity which can result in putting them off balance and constant strain.

In an ergonomic perspective, bad vehicle design is an external stress factor, which affects the internal biomechanical feedback of human body. The lack of supportive design features limits normal postural changes leading to the static entrusting of otherwise dynamic working muscles and tendons. Such ergonomic variations are further enhanced by congestion and long commute in the developing cities such as Karachi whereby the transport system infrastructure is said to be barely standardized. It is not the ergonomic theory, which is preoccupied with the comfort of the individual, then it is the paradigm of intervention in the health of the community. The ergonomic theory can be used to supplement the systems level approach in which prevention of MSDs is not merely pursued through reorganizing the behavior of individual, but also structurally and infrastructurally changing it.

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This is also increased in the biopsychosocial health model which takes into account interdependence of the physical, psychological and social factors in the development and the progression of musculoskeletal disorders. In this model, no human being is able to separate the human experience of pain and malfunction of the body, cognitive and emotional responses, social expectations and physiological processes of stress. The biopsychosocial model can be applied to the students of the physiotherapy sphere in particular as they are a dual learner in the rigid academic setting and an individual who will have to cope with the stigma of the physical and environmental conditions on a daily basis. The stress in school, excessive time studying, working in the clinic and commuting is all the causes of the increased sympathetic activity and reduced recovery capacity. These psychosocial stresses in a vicious cycle with mental strain and physical pain can increase the sensation of pain and delay the healing of tissue.

Furthermore, the biopsychosocial model is concerned with the existence of perception and coping approach of an individual as one of the factors in changing the effect of external stressors. The musculoskeletal burden of the commuting process can be varied in two students whose outcome can vary based on the resilience, stress tolerance and health behaviors. This difference depicts how genetic predisposition, psychological adjustment, and being exposed to an environment interplay. Students of physiotherapy, even having knowledge about proper postures and ergonomics, cannot adhere to preventive measures regularly because of the context-dependent factors like lack of available means of transport, time, or exhaustion. The biopsychosocial model is therefore underlining the fact that knowledge is not enough to prevent it; behavior translation within the environment, and institutional frames is necessary.

2. REVIEW OF RELEVANT STUDIES

The process of urbanization has become one of the topmost concerns during recent decades, which resulted in population overcrowding in the cities and a significant increase in the number of personal vehicles. It has facilitated economic activity, and movement of people but it has also become a source of issues like traffic jams, air pollution and health hazards associated with unhealthy emissions. Sustainable mobility and public transport have consequently become the focal point of the development discussion on urban development, and such approaches as electric cars, buses running on biogas, smart transport technology, and combined services such as Mobility as a Service are discussed on the global level. These inventions are meant to cut the carbon emissions, enhance the efficiency and offer safer and reliable means of travel other than privately owned cars. Nevertheless, the problems still exist, and most cities still do not have access to affordable and convenient transport systems, informational and unsafe forms grow, have also aggravated mobility patterns (28).

On the same note, traffic jam is an increasing urban problem in the global scene, but its severity is more pronounced in aspects of developing nations like Afghanistan whose level of service provision coupled with extreme population growth aggravates the situation. The fact that numerous factors affect the delays, pollution, and loss of money has been pointed out by studies that have concentrated on Kabul and these factors include poor road networks, poor road management, lack of proper

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provision of transport to the people, and unregulated human behaviors, which all lead to delays, pollution, and loss of revenues. One of the strengths of this study lies in the application of both primary (questionnaires and group discussions) and secondary data, providing an overall understanding of the causes and effects of congestion and providing such practical solutions to the issue as the improvement of the infrastructure, imposition of traffic laws, and the growth of public transport. Nevertheless, there are still limitations, with the majority of the evidence being only context-specific to Kabul and based on qualitative techniques and not having strong quantitative indicators, like the amount of traffic motion or the pollution rating. These limitations limit the generalizability of the results, but also suggest that additional empirical and comparative studies are necessary to support the informed selection of sustainable traffic solutions in other developing cities along the same lines. (22)

Moreover, transport reduces congestion, pollution and accidents besides allowing accessibility. It enhances movement in urban areas and social justice through reasonable means of transport. The SERVQUAL model evaluates the quality of service by using the measurement of reliability, responsiveness, assurance, empathy, and tangibles. The studies have shown that there is a gap between the expectations and the quality of services delivered by the airline to people, which leads to dissatisfaction. Other significant flaws include reliability, comfort and safety which have a significant effect on user perception. The efficiency of the public transportation depends on improved policies and infrastructure. (5)

The consequences of the importance of the public transport are that it would reduce the traffic, fuel consumption, pollution, and road accidents in comparison to the use of the private cars. Nevertheless, it is being decreased in most places as people rely more on the automobiles, more traffic and services are inaccessible. Improved transport systems can be made more linked and easier to access, improve the reliability of the transport methods, and enhance comfort to passengers. Money is another huge issue as the ticket fees often cannot meet the expenses and therefore additional backing or alternative funding is required by the governments. The gaps of the existing research are identified as the fact many studies are dedicated to policies and finance and are less concerned with passenger needs such as comfort, safety, and reliability. The lack of research on the potential improvement of the transport systems by new technologies or the fair different ways of funding people of various income levels is also insufficient. (19)

Musculoskeletal disorders (MSDs) are inflammatory and degenerative disorders that attack muscles, tendons, ligaments, joints, and peripheral nerves. According to the World Health Organization (WHO), there are more or less 1.71 billion individuals in the globe with MSDs. Among the MSDs, back pain is reported to be the most prevalent in the world, with 568 million individuals affected by it, and this has been the leading cause of disability in 160 countries. MSDs are an important occupational health problem, which has accounted half of all occupational illnesses as well as approximately one-third of all absenteeism leaves by healthcare workers are connected to MSDs of the neck, shoulder and back. Demographic and physical factors are not given so clearly; certain studies suggest that there is a systemically higher prevalence of MSDs among women than among

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men, whereas other studies attribute a high Body Mass Index (BMI) to MSDs. Pain and, second, stiffness are the most frequent symptoms. It also identifies the areas that were most affected in all of the staff (knees 11.1%, low back 10.2%) and by group (neck in drivers and knees in security guards and sweepers). There are however a few limitations in the study, which is mainly the non-probability convenient method of sampling, which could be a source of bias. The sample is mostly male (88.6%), which is contrary to some studies in the world that indicated that the prevalence of MSDs among females is higher. (37)

Majority of recent research on musculoskeletal disorders in bus drivers has been based on validated self-report instruments most commonly the Nordic Musculoskeletal Questionnaire (NMQ) has been used to measure prevalence of pain in various body parts. Recent studies point out that bus drivers experience extremely high rates of musculoskeletal disorders (MSDs), and a comprehensive meta-analysis estimates that the prevalence is some 74 across the board, with the lower back, neck, and shoulders being the main targets. Research in various work environments also establishes that prolonged sitting, whole body vibration, awkward poses, excessive working hours and lack of rest or relaxation time are among the risk factors. Furthermore, more recent studies also found psychosocial stress and low sleep quality to contribute to multi-site MSDs in bus drivers, which means the physical load is aggravated by the actions of the human mind and behavioral system. (42)

Most bus drivers suffer the main problem of Musculoskeletal disorders (MSDs) as a result of the prolonged sitting of the bus driver, improper ergonomics of the bus, and work stresses. As explained in the studies, the neck, shoulders and the lower back are the notable regions, which are involved. The issues that have led to this include wrong sitting, unnecessary movement and brain stress. According to some research findings, the time lag between shift and ergonomics e.g. improvised chair design would assist in alleviating the pain. It is possible that the working environment and job stress can be addressed to make the act of driving more comfortable and even job-satisfying by a significant margin (41).

Bus drivers suffer more complications related to musculoskeletal disorders (MSDs) because of repetitive movements, bad postures in the body and prolonged sitting. Shoulders, neck and lower back are the most affected. The major risk factors include stress, whole body and substandard design of seats. Research has shown that pain can be reduced with the aid of certain ergonomics such as better seating and frequent rest (43).

Moreover, bus drivers have a considerable risk of musculoskeletal pain (MSP) because of the durability of sitting, repetitive work, and working conditions. Research has determined that neck, back and shoulder are very susceptible to MSP that causes mild-moderate level of disabilities. The drivers of the heightened discomfort and health complications can be explained by such factors as the design of the seats, as well as the condition of the roads and excessive working hours. It has been shown that the ergonomic interventions and rehabilitation programs are necessary to prevent and treat MSP. The research justifies the necessity to better the environment under which the drivers work and to amend the policies and enhance the welfare of drivers. These problems are solvable to promote the bus driver occupational health and safety (44)

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The central question of the paper is to research the prevalence of musculoskeletal disorders (MSDs) among heavy vehicle drivers and the workforce of the transportation departments in terms of a machine learning strategy. It describes the lower back pain (LBP), knee pain (KP), and neck pain (NP) as the most common MSDs in the two populations. An adapted Nordic Questionnaire was used to collect the information in 48 drivers and 40 people working in an office. The Bayesian model revealed that the NP was a factor in KP which led to LBP. Long periods of sleep also had the effect of lowering NP and the Logistic regression had singled out the age as a significant risk factor of the LBP. The results reveal that there is no distinction between the rates of pain among these two occupational groups and this proves why there is need to make some ergonomic interventions. This publication brings out the possibility of machine learning to analyze the interacting relationship between the risk factors of MSDs in a complex way. (8)

Similarly, bus drivers are also susceptible to Musculoskeletal disorders (MSDs) that include muscle, tendon, ligament, and other structure-related issues and in most instances caused pain and bad work performance. Age years of work experience, excessive work hours in driving, poor posture, whole body vibration, and certain physical activities have already been identified to be major causes of MSDs among this group of people. The risk is also increased by other factors like smoking, work stress, work dissatisfaction and psychological strain like anxiety in driving up the process. When measuring MSDs, the most studies employed the Nordic Musculoskeletal Questionnaire (NMQ), a universal and standardized system that aids in the assessment of pain and discomfort in different bodily regions, which is also very convenient with work populations, including drivers who have to overcome repetitive stresses and unnatural positions. Also, most of the researches are concentrated on specific aspects, thus, leaving gap in the literature about cultural, environmental and organizational aspects on the wellbeing of drivers. To address these gaps, more general, more thorough research could be used to obtain a better insight and create preventive strategies to curb the MSDs to improve the safety of drivers and the effectiveness of the public transport system. (45)

Low back pain (LBP) is a significant work life health problem among professional drivers and the study done in Bangladesh demonstrates that the prevalence of LBP is very high in intercity bus drivers with a high rate of association by age, income, long working hours, extended sitting, poor seat quality and lifestyle behaviors including smoking and drug use. The paper affirms that the primary causes of musculoskeletal strain are ergonomic complications, vibration of the whole body and insufficient rest intervals. Although its results offer useful information to policymakers to develop low-cost strategies against this issue, including seat manipulation, rest, and ergonomic training, the study has certain limitations related to its cross-sectional character and use of self-report measures and the lack of consideration of such psychosocial and night-shift elements. Furthermore, since another context-inappropriate study could be the presence of LBP in any other low- and middle-income nations, especially urban transport systems, additional studies have to be conducted to fully comprehend the LBP risk amid various groups of commuters, such as people accessing public transport and students. (46)

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Recent research on the auto rickshaw drivers in India showed that persistent low back pain was highly prevalent (48.16), which was majorly as a result of prolonged sitting, vibration of the whole body, absent lumbar support, and unhealthy lifestyle patterns. Demographic and family risk such as male sex and musculoskeletal disorders in history also predisposed the vulnerability and smoking and inactivity of the symptoms. The results highlight the necessity of immediate ergonomic adjustments, rest intervals and health awareness interventions among the drivers. Nevertheless, the study was only conducted among one occupational group and the psychosocial factors of LBP had not been explored entirely and this is where subsequent research can be done in the context of various groups of commuter groups, such as students and users of transport in other low-and-middle income nations. (47)

The user of public transport is regularly subjected to musculoskeletal issues due to the long traveling time, the poor design of the seats, the overpopulation, and the vibrations during the movement. Studies have identified the lower back, neck and shoulders to be the most influenced ones with the pain being attributed to sitting, awkward posture and standing in small spaces. Research has also indicated that high levels of discomfort were reported by students particularly those who have to commute to school at a distance, because commuting stress is compounded by inactive lifestyles during studying and heavy wearing of backpacks. Although the public transport is crucial to mobility and sustainability, there are still gaps in investigating the influence of these groups on this matter, and scarce research existed in the cities of South Asia, such as Karachi. (40)

Available studies discuss the prevalence of musculoskeletal disorders (MSDs) in those using the public transport in Lahore and identify prolonged sitting, repetitive musculoskeletal strain, and poor ergonomics as some of the biggest risk factors. An example where a cross-sectional survey was undertaken on 212 participants showed high rates of MSD symptoms, with the most prevalent ones being the neck (54.2), upper back (57.1), and ankles/feet (59.0). Most of the cases were of medium severity (70.23%), which is a significant public health problem. The research proposes ergonomic interventions to be used and awareness campaigns done to curb against the dangers of MSD. Finally, it highlights the urgent need to advance the transport ergonomics to improve the passenger welfare. The study focuses on users of public transport indicated prevalence of MSD but omits some important details such as the cross-sectional nature of the study, use of self-reported data, and non-probability sampling to restrict causality and generalizability. It restricted itself to Lahore, with no ergonomic testing, psycho social, or environmental evaluations or later follow-up. Short travel times were also not reported and they did not consider risks in long distance commuters. These gaps have led to a wider contextually relevant study, as in Karachi, including the role of ergonomic and psychosocial aspects. (11)

Equally, the study examines the issue of musculoskeletal pain in commuters who use the local trains in Mumbai, a common issue which can be explained by congestion and the uncomfortable postures. It stresses the outcomes of repetitive loading and poor ergonomics citing other studies that are related to musculoskeletal disorders (MSDs). The Nordic Musculoskeletal Questionnaire was used to determine the prevalence of pain and found out that discomfort was experienced by 86 percent

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of riders. The neck area (37%), lower back (36%), and ankles/feet area were the most common ones (33%). Other studies in the past highlight the same threats associated with prolonged standing and holding static postures. The findings can be compared with the available literature regarding health challenges associated with urban transit and the conclusions are that there is a need to implement ergonomic solutions. Also, the study offers valuable information on gender variation, whereby women are more vulnerable to pain. (10)

The research problem discussed in the article examines the prevalence and risk factor of musculoskeletal disorders (MSDs) in commuters in Selangor, Malaysia by the utilization of the Nordic Musculoskeletal Questionnaire (NMQ) as the main measurement instrument. It underscores that prolong upright postures, monotony of activities, absence of ergonomic support, and occupational requirements are major factors that create discomfort mostly to erratic parts such as the neck, shoulders and the lower back. The research is consistent with the existing literature highlighting the burden of MSDs in working and commuting setting since it is consistent with the results of Patil et al. (2018) and other studies of regional transport users. The study contributes to the current research on MSDs in urban populations, affirming that ergonomics, posture correction, and preventive measures are significant by quantifying the symptoms with using standardized instruments. (48)

This paper addresses the application of the Theory of Planned Behavior to the Karachi Circular Railway (KCR) that is adopted as a mode of public transportation. To measure their attitudes, subjective norms and perceived behavioral control (PBC) concerning the use of KCR, a questionnaire survey that was conducted on 385 participants to assess their perception on the use of the KCR. These results imply that subjective norm plays a major role on this willingness of the people to use the KCR especially in the education system. The transportation preferences are also affected by gender and employment. It highlights the need to improve the quality of the available public transport to ensure that more people accept it, which benefits the policymakers involved in trying to improve mobility in Karachi by providing quality transport services to the population. (1)

The literature indicates that there are few industries that record very high prevalence of occupational health issues, the transport sector is one of them and work-related musculoskeletal disorders (WMSDs) are the most prevalent. Bus drivers are impacted especially on lower back and neck pain, which are normally reported as a result of protracted sitting during work, awkward positions and entire body vibration as well as infrequent work schedules. Job insecurity, harassment and overworking are also psychosocial stressors that aid in the development of anxiety, depression and burnout that is closely associated with musculoskeletal pain. Risk may include age, BMI, and years of service, but the factor of resilience may possess the protective qualities. This paper provides a solution to this gap because self-reported questionnaires are supplemented by an ergonomic motion-capture analysis, which gives a clear picture of both physical and psychosocial risks. The study strengths are that it is a mixed-method study, it utilizes a large sample and it employs validated and reliable instruments such as Nordic Musculoskeletal Questionnaire, Copenhagen Burnout Inventory, and Dede static-21. It also notes the effect of the bus type and route conditions on the

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outcomes of health. The weaknesses are, however, the use of self-reported data, small Phase II sample, potential selection bias, absence of multivariate analysis, and omission of other occupational hazards. Nonetheless, the research is rich in information about the health issues of bus drivers. (34)

Despite the importance that women in Low-and-Middle-Income Countries (LMICs) assign to public transport, study on their safety during the commuting process is not comprehensive and has been unevenly covered with majority of studies being conducted in South Africa, India, and Malaysia and many more areas being underserved. Available information reflects typical issues typical to harassment, fear of assault and lack of reporting of sexual violence and the adverse effect on the health, confidence and socialization of women. Much of the studies, though, are anchored on surveys and quantitative data, paying very little consideration on cultural and personal experiences that inform the sense of safety of women. This is not enough because it allows critical gaps in the comprehension of the bigger picture since it does not use diverse methods and cover a broader country picture. The way forward would be to conduct more balanced and context-specific studies, falsehood of the policy and awareness approaches that can be used to increase safety and allow women to gain equal access to public transport services. (14)

Research that has been carried out thus far examines the commuting time effects on the health of the workers based on large survey data portraying that increased commuting times are associated with worse self-report health outcomes. It underlines the idea that low intentions to exercise are one of the main pathways in which extended commutes impact the well-being negatively and adds that the relation between commutes and well-being depends on additional factors, including gender and work hours. The gaps in the research are that other potential mechanisms like stress, quality of sleep and psychosocial strain are not studied comprehensively and the results are contextually limited thereby limiting their externalization. Also, the short-term consequences and test intervention approaches are not discussed in the study, and the future researches will have gaps to conduct causal analysis, objective health evaluation, and general factors determining commuter health (49)

This paper has investigated the effects of the commuting time on musculoskeletal pains, how the relationship is mediated by working hours and working during shift. The authors used statistics of the Sixth Korean Working Conditions Survey that consisted of over 28,000 paid workers and found that back, upper extremity and lower extremity pain were significant at a higher rate among the employees with longer daily commuting. The risk increased even further in the staff who worked more than 52 hours per week or shifted meaning that the long commuting and work demands are synergistic to aggravate musculoskeletal health. The article has strength as it is based on a big nationally representative sample, boasts of good statistical correction of the factors that may should have influenced the results such as demographic and ergonomic and psychosocial factors and that its analysis is stratified which further elaborates the results. Notably, it also adds to the existing knowledge through the connection of commuting hours with not just the presence of pain but also with occupational variables, including working schedules and hours, which provides a more integrated picture. Nonetheless, the study is cross-sectional, which limits the ability to interpret the results in a causal way, whereas choices of using self-reported pain measures create a risk of recall or

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reporting bias. Irrespective of these, the study is the evidence showing that long commuting, particularly commuter work conditions combined with demanding work draws are an imminent danger to the musculoskeletal health. (35)

The proposed study, the effect of commuting time on burnout: the mediation effect of musculoskeletal pain, is a significant contribution to the body of literature on occupational health because it aims to identify the interrelation between commuting time, musculoskeletal pain, and burnout among employees in the field of health care. The study, which used a big sample, 1615 participants, in Taiwan in a cross-sectional study, helped determine one of the key findings: the duration of commuting to work larger than 50 minutes is directly linked to a higher risk of personal burnout. More importantly, the mediation analysis was employed to prove that neck and both shoulders pain (NBSP) is a crucial mediating variable, i.e., the long commutes worsen NBSP, which, subsequently, increases the likelihood of personal and work-related burnout. This established the fact that the commute time, and not the mode of transport are the most significant risk factors. The significant strength of the study is that the sample size (1,615 healthcare workers) is large and that the measurement devices, i.e. the Copenhagen Burnout Inventory (CBI) and the Nordic Musculoskeletal Questionnaire (NMQ), are validated and standardized. (36)

The article discussed the mediating process of the effect of physical activity on the musculoskeletal health between non-ergonomic sitting posture and physical activity in professional bus drivers. Past literature identifies that musculoskeletal disorder (MSD) is very common in drivers primarily because of prolonged sitting, repetitive force, poor posture, and whole-body vibration with majority of drivers reporting lower back, neck and shoulder pain. The exercises have been found to be effective in reducing the risk of MSD but the opposite is true of sedentary activities which increase the medical problems. An assessment of 115 Croatian bus drivers aged between 40-55 years was done using Orebro Musculoskeletal Pain Questionnaire, Rapid upper limb assessment and the use of pedometer to test activity. The results indicated that 95.6 percent of drivers had musculoskeletal pain with the lower back showing the most symptoms (70.4 percent). The findings were that the negative effect of poor posture may be countered by an increase in the extent of physical activity. These findings are consistent with what the existing sources show and indicate the importance of ergonomic interventions and physical exercise in the prevention of musculoskeletal problems in bus drivers. However, it is restricted in that it has a small sample, convenience based which is restricted to male Croatian bus drivers in the range of 40-55 years; hence, restricting its applicability to other populations, including female drivers. (38)

The wellbeing literature has progressively attributed commuting to be an important determinant with majority of the studies reporting presence of stress, fatigue, sleeping disturbance and lower level of life satisfaction with increase in commuting time. Although there is some indication that a short commute can give one time to relax or even ease between work, and NFL, longer commuting is always associated with negative health effects, less family time, and even poor social life. Nevertheless, much of the literature has been centered on the western context and little emphases has been placed on the low- and middle-income countries where overcrowding, poor transport infrastructure, and

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inadequate ergonomics could compound on musculoskeletal and psychological health. This gap shows the necessity of contextual research to comprehend the impact of commuting conditions on wellbeing among different groups of people. (50)

Micromobility is a new phenomenon, which is quickly spreading in urban transport; nowadays, it is common to find bicycles, e-bikes, e-scooters, and other small electric vehicles in cities throughout the world. The feature of these modes is the flexibility, being quite affordable, and offering first- and last-mile services to other sources of transportation to decrease the number of personal vehicles and create more sustainable mobility systems. Nevertheless, there are still issues, such as regulation, infrastructure requirements, parking, and fair access. Although the current research is mostly done on bicycles, only very limited research has been done on the other micro-vehicles. This throws some very significant gaps on the perception of the user behavior, safety, the adoption of technology and how policies contribute to the integration. Additional studies are necessary to ensure that planners and policymakers develop systems that can harness the potential of micromobility in sustainable transportation in the city (20).

Moreover, recent studies explore the necessity of the public transportation in Colombia cities, which identify the most important factors which influence the market shares. Using aggregated choice approaches it calculates elasticities of price, income, speed and frequency, which indicates that demand is highly elastic to price and frequency but to some extent to speed. This is because the elasticity of income is negative, which implies that there exists a negative income elasticity resulting to the classification of public transportation as an inferior good. Moreover, the study advances the need to put these factors into consideration when making transport policies, particularly in developing countries. These findings present the necessary information towards improving urban public transport. (2)

Studies concerning public transport planning have always been unable to strike a balance between the social values and the aims such as efficiency, cost reduction, and the environmental conservation. Majority of the research is conducted on accessibility of systems that have already been developed, as opposed to forecasting impacts at the planning level. To proceed, new ideas to be socially inclusive and practical are required to ensure that the transport planning promotes the concept of sustainable accessibility, in which equity, efficiency, and environmental objectives are taken into account. (31)

An effective solution to this problem is developing effective public transport systems, which proves to be a challenging issue in the conditions when control is distributed among numerous participants, and coordination and cooperation is needed. A review of literature reveals that although consensus is reached in the actions that should be taken to enhance public transport, however, less is definite in implementing these changes. Discoveries show that most of the nations though they may have diverse legislations and structures have the same issues in planning and ensuring good systems are used in their work. In many cases, it is the nature of the design of legislation and governance that causes impediments to the realization of simplicity, good service and increased use of public transport. It makes it clear that even more feasible methods are necessary to address institutional complexity and enhance user outcomes. (29)

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The study of the commuting by public transport has become more focused on its impact on physical and mental health and earlier research going back to 1986 has investigated the impact of bus, train, subway, tram, and metro travel. There is 47 empirical study evidence indicating that commuting is leading to increased sickness, sleep deprivation, stress, and health complaints with rail commuters, in particular, displaying high levels of cortisol, perceived stress and negative emotional reactions to crowding. To a large extent, though, this is greatly based on self-reported information, as opposed to objective physiological or behavioral indicators, thus limiting the in-depth comprehension of causal pathways. Nonetheless, the results all focus on the fact that stress-reduction and well-being of commuters should be controlled with the help of organizational and policy-level interventions including the flexible work schedule that could have an alleviating effect. (21)

3. GAPS IN LITERATURE

The available literature is mainly based on developed countries where there are well-established systems of public transport and there is limited evidence on the same in developing urban settings like Karachi. South Asian cities are characterized by the infrastructural instability, vibration and overcrowding of their cars, poor ergonomic conditions therefore constitute special biomechanical stressors in the available global data that are not adequately captured.

The vast majority of research concerning the issue of musculoskeletal disorders (MSDs) in commuters suggests that employers, like professional drivers or office workers (34, 45), are susceptible to the problem, yet the younger generations, who have a strong dependency on using time-saving transportation methods to get to schools or colleges, are not discussed. This exclusion provokes a serious gap in knowledge on the cumulative postural stress and ergonomic difficulties students have to face at the age of 18 to 26.

Most of the previous studies analyze people who have a long journey period (35), but not those who have a short journey but frequent ones- a habit that is typical among students at the city. The micro-exposures to vibrations, strained posture and dynamic loading which are repetitive might result in chronic musculoskeletal adaptations which are minimally researched at the moment.

The available literature has more of musculoskeletal pain prevalence and distribution as opposed to assessing awareness levels, ergonomic knowledge, or the uptake of preventative measures, including stretching, posture, or load management. It has not been investigated into whether such awareness can result in consistent preventive behavior among physiotherapy students who have theoretical knowledge about body mechanics, a significant gap appears between the knowledge and its practical use.

Many of the regional studies use self-developed or non-standardized questionnaires, which do not allow reliable or comparable results to be made across studies. Thus, there is an urgency to use validated musculoskeletal evaluation tools including Nordic Musculoskeletal Questionnaire to guarantee both the methodological rigor and context-relevance of the public transport users in Pakistan.

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METHODOLOGY

1. STUDY DESIGN

The current study was a cross-sectional design and was conceptually based on its ability to address a multidimensional picture of the variables of health issues in a certain population setting. The design was also pretty well adapted to the investigation of the interaction between environmental exposure and musculoskeletal health in students of physiotherapy who have to use public transportation as a part of their daily routine, which is why due to this fact the combination of the professional knowledge of body mechanics with the ergonomic strain experienced in everyday life became inherent to this group of the population. The cross-sectional design was favorable since it enabled the simultaneous study of several determinants- including duration of commute, seating position along with transport conditions- thus, showing the extent in which these determinants jointly contribute to the distribution and severity of musculoskeletal symptoms in the critical weight-bearing and sensitive parts of the body.

In addition to its practical merits, this design is conceptually covered by the overall objective of the study: to clarify how the daily physical and biomechanical demands of urban movement can affect the working well-being of future medical workers. The cross-sectional framework will facilitate reflective knowledge of the realities of today and make informed speculations on future longitudinal, experimental, or ergonomic intervention research by expropriating the patterns of association rather than causation. Therefore, it not only reflects an analytical bridge between the environmental experience and professional health literacy, as well as musculoskeletal resilience, but it is also a descriptive one.

2. STUDY SETTING

The study was carried out in a sample of academic institutions of medical and physiotherapy field in Karachi, both in government and within private and government- sector universities and colleges, to generate wide demographic, institutional and environmental presence. As the largest metropolitan hub of Pakistan, Karachi is a peculiar socio-geographical location due to its great population density, diversified infrastructures, and high dependence on the existing transport systems. This setting offered a perfect setting to explore musculoskeletal and ergonomic consequences of regular commuting among physiotherapy students who despite their education on posture and biomechanics are constantly subject to the physical challenges of urban travel.

The strategic choice of institutions in various districts of the city was taken to bring some variations in commuting patterns, travel time and means, including buses, vans, rickshaws, and shared ride services. This heterogeneity enabled the research to capture the heterogeneity of the transport experiences by the student characteristic of Karachi student community. The provision of centrally and peripheral campuses also helped to represent a range of students with various journey distances i.e. both short intra-district and long inter-district, and thereby, captures the geometric of musculoskeletal stress of distance, vibration, and sitting.

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Data were collected in academic settings, mostly in classrooms, seminar halls and selected student lounges in controlled comfortable settings that did not cause much interference in the normal learning programs. This method entailed a sense of participant engagement and sincerity of answers since the research is placed in a context that is familiar to the participant in terms of institutions. The environment also helped the researcher to uphold confidentiality, standardization in administering the questionnaires and adherence to ethical guidelines.

The research design placed the study in the context of the varied educational and transportation infrastructure in Karachi in that it not only placed the issue of musculoskeletal health in a real-life commuting setting but also highlighted the degree to which the academic life, urban design, and preparedness to occupational health became interwoven in physiotherapy profession future.

3. DURATION OF STUDY

The overall study time was roughly six months which included all project phases such as planning all the way to the end. This was actually planned to have the flow of research activities organized properly and keep in sync with annual academic calendar of physiotherapy institutions in Karachi to make sure that data collection would be done without interfering with the studies of the students. The research commenced by a preparatory stage and this involved a careful examination of the existing literature that would enhance the evidence that was present and the gaps that were found and areas that needed to be filled with research. This was also the stage where ethical approval was given to ensure that every procedure was done according to the academic and institutional ethics.

The data collection phase was started after permission was granted. This phase took over several weeks, since information was collected in various physiotherapy and medical centers in Karachi. The researcher liaised with the head of departments and faculty such that suitable time would be set to collect the data. There were also questionnaires that were administered and filled at an academic setting like the classroom to ensure that the measure of comfort, confidentiality and standardization were upheld.

The last stage of the research was aimed at data organization, verification and statistical analysis. All the collected data had been reviewed considering gaps or inconsistencies and then subjected to the final analysis. The long period allowed a reasonable time interval to do the interpretation and validation of the findings, which led to the overall reliability and thoroughness of the research.

Overall, the six-month project facilitated the procedure of executing all the phases of the research including design and analysis systematically, ethically, and economically to optimize the research findings in terms of quality, accuracy and credibility.

4. POPULATION AND SAMPLING

The target population was the students of the undergraduate course in the selected medical and physiotherapy colleges in Karachi. The specific sample was selected as it is a representative of the young adults who use the public transport to reach school which is directly connected with the objectives of the study. The focus of these students provided an opportunity to investigate the

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musculoskeletal load which could be provoked by the daily commuting habit and the total load on the posture during the commuting.

The participants who satisfied the inclusion criteria were selected with the help of non-probability purposive sampling technique. This approach allowed the researcher to choose the people who used the public transport regularly with the purpose of obtaining the relevance and accuracy of the information. The method also had the advantage of sampling the participants with varying institutional backgrounds, and the variation in commuting distance, mode of transport and frequency of travel could be factored. The purposive sampling, which was non-probability, helped the study to obtain a more contextually valid and representative image of the musculoskeletal health issues related to transport among the targeted population.

5. SAMPLE SIZE AND TECHNIQUE

The sample size has been calculated with respect to earlier studies referring to musculoskeletal symptoms with analogous groups of students and modified to ensure a pertinent statistical strength to trace meaningful relationships. The Open Epi Sample Size Calculator was used to calculate the size of the sample used in the study; this is a total of 322 participants. It was computed using an estimated prevalence of 72.6 which was given by a previous study, a 95 percent confidence interval and 0.05 margin of error because the study was done among physiotherapy students of several medical schools in Karachi. The formula formed was $n = Z^2 \times p \times (1 - p) / d^2$, n was the size of the sample, Z is the confidence level (95%), p is the target prevalence (72.6%), and d is the margin of error (0.05). A set sample size was deemed adequate because it would reflect descriptive and inferential analysis of the study within the available resource and time constraints.

6. INCLUSION AND EXCLUSION CRITERIA

To ensure the selection of a homogeneous study sample and to minimize potential confounding factors, the following inclusion and exclusion criteria were established.

INCLUSION CRITERIA

- Age 18-26
- Both Male and Female
- Individuals who commute using buses and rickshaws regularly.
- Individuals who use public transport regularly for at least one year as their primary mode of travel.
- Individuals who commute in both seated and standing positions while travelling.
- Individuals who carry academic/professional load (e.g., laptops, books, instruments) while commuting.
- Individuals who travel during peak commuting hours (morning/evening rush hours), as this increases crowding and musculoskeletal strain.

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- Able to read, understand, and complete the questionnaire independently.
- The study population will specifically include undergraduate physiotherapy students who fulfill the above criteria.

EXCLUSION CRITERIA

- Individuals who exclusively use private vehicles as their primary mode of transportation.
- Those who use ride-hailing services (e.g., Uber, Careem) for most of their commute.
- Individuals who frequently switch between public and private transport (e.g., alternate weeks).
- Individuals with recent hospitalization (>1 week in the past 6 months) that may alter physical activity levels.
- Individuals with a history of recent surgery, fractures, or other musculoskeletal trauma.
- Pre-existing neuromuscular disorder.
- Pregnant women.

7. DATA COLLECTION TOOLS AND PROCEDURE

The data required in this study were gathered with the help of the Extended Version of the Nordic Musculoskeletal Questionnaire (NMQ) that is a globally recognized and validated instrument designed to determine the prevalence, distribution, and effects of musculoskeletal discomfort in various body parts where the severity scoring was determined in terms of the standard NMQ version in order to remain clear, concise yet comparable to the prior investigations. The NMQ was chosen because of high reliability, cross-cultural and clinical applicability in measuring work related and activity induced musculoskeletal disorders. To be able to conduct this research, the questionnaire was extended and contextualized to meet the commuting habits and academic schedules of physiotherapy students at Karachi.

The revised version took into consideration the use of more parameters including the frequency, intensity, and duration of the symptoms reported thus being able to understand the severity of the symptoms in a better way and the potential connection to the elements of transport including the duration of commuting, the positioning, and the mode of transportation. This improvement added an additional level of analysis to the tool enabling descriptive and inferential statistical analysis of musculoskeletal outcomes.

The collection of data was done physically, in the academic premises of the institutions participating in the research, and under supervision of the researcher. This would give procedural consistency across settings and the possibility to clarify any concerns or ambiguities of participants immediately whilst completing the questionnaires. It also reduced the chances of distributing or missing responses hence upholding data integrity. The objectives, the measures of confidentiality of the research and the right of the participants to voluntary structural disengagement were clearly explained. The informed consent was written before the participation basing on the ethical principles of research.

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After this, the questions in each questionnaire were read thoroughly to make sure that they were correct, complete and legible and then coded and typed into the dataset to be subjected to statistical analysis. Systemic supervision and verification process that showed the validity, reliability and the overall quality of data ensured that the data obtained was the true picture of musculoskeletal health profile of the target population.

8 VARIABLES (INDEPENDENT, DEPENDENT, CONFOUNDERS)

The independent variable in this study was the use of the public transport since it covered the mode of transport, duration of such travels and frequency of commuting. The dependent variables included the occurrence and intensity of musculoskeletal symptoms experienced in the various parts of the body, measured using the NMQ. A set of demographics, physiological, behavioral and environmental variables that had the potential to cause independent effect on musculoskeletal outcomes were included as potential confounding factors in the study of the muscle-skeletal result in physiotherapy students. These were age, sex, academic year, and body mass index (BMI), and extent of physical activity, which has been identified to influence musculoskeletal strength, endurance, and discomfort susceptibility. Other confounders that were used in the analysis included time of study-associated sitting, electronic gadget usage, sitting position or postures used during academic work, and prior history of musculoskeletal injury or chronic pains, which could predispose the person towards recurring or worsening symptoms.

The variables of lifestyle including the quality of sleep, the stress level, and commuting position were also recognized because both the perception and expression of pain can be modified by psychosocial, as well as ergonomic influences. Moreover, mode of transportation, time taken in commuting, vibration or uncomfortable seating ergonomics were also identified to be the possible confounding factors in commuting and musculoskeletal strains. Indirectly, variables in institutions such as academic workload, ergonomics of classroom, and the availability of physical activity facilities could have played a role in variability of musculoskeletal health outcomes.

The article attempted to reduce bias and maximize internal validity and interpretive accuracy of exposure-musculoskeletal disorder relationships among physiotherapy students who were exposed to public transport in a sequential fashion and computed these confounding variables.

9 DATA ANALYSIS PLAN

All the data collected was coded and entered to the Statistical Package of Social Sciences (SPSS) version 27.0 in order to analyze them. The frequency, percentage, and mean were described by the participant characteristics and prevalence of the symptoms by region of the body using descriptive statistics. The test used was to infer relationships between commuting factors and musculoskeletal symptoms by utilizing inferential statistical tests, e.g. Chi-square tests of categorical variables. The p value was determined at 0.05. The correlations between musculoskeletal pain and commuting problems were analyzed using Spearman's correlation. The interpretation was achieved with the help

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of graphics and tables, whereas the validity and reliability of findings were guaranteed by careful data cleaning and check.

10 ETHICAL CONSIDERATIONS

Before the data collection, ethical approval was given by the respective Institutional Review Board (IRB) to observe the internationally accepted research ethics when conducting research on human participants. The research was conducted and planned according to the Declaration of Helsinki and institutional research ethics regulation and guaranteed dignity to human beings as well as the well-being of the participant involved in the research.

The participants were given exhaustive information about the purpose, objectives, procedures and implications of the study. They were made clear that they were volunteering and that they could refuse or pull out at any point without any academic or personal repercussions. To strengthen the element of transparency, the participants were informed on how much it was expected to take to complete the questionnaires and the kind of information to be sought so that the they made informed and independent decisions.

The signed informed consent form, which indicated a voluntary agreement of the participants to participate in the research, was signed by each of the participants before their inclusion. The questionnaires were kept confidential and anonymous no identifying information (e.g. names or roll numbers) was listed on the questionnaires. Any information was coded, safely kept and done only in the hands of the researcher. The data gathered was utilized on an academic and research scale only and the privacy and integrity of the participants were ensured.

The four basic ethical principles, which included autonomy, beneficence, non-maleficence, and justice, were followed in conducting the study. Autonomy was maintained by way of voluntary participation and informed consent; beneficence and non-maleficence were observed by reducing any potential physical and psychological risks; and justice by having a fair and equal sampling of the participants in the various institutions. The principles kept the research ethically sound, ensured that participants were able to trust in the research, and that the research itself was scientifically sound, therefore ensuring the overall integrity of the study.

RESULTS

1 DEMOGRAPHICS OF PARTICIPANTS:

There were 322 respondents participating in the study. The average age of the respondents was 21.9 with a standard deviation of 1.62 years old (18-26). The sample size was mostly female (92.5 %), and caused male participants to be 7.5% of the total number of participants, which suggests that the sample was vastly female. Table 1 and 2 shows the age and gender of the participants.

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Sociodemographic characteristics of participants:

Table 1 Age Distribution of Participants (N = 322)

AGE (Y)	N	Minimum	Maximum
	322	18	26

Table 2 Gender Distribution of Participants (N = 322)

GENDER	Frequency	Percent
Male	24	7.5
Female	298	92.5
Total	322	100

Response Rate:

There were 322 respondents (n=322) physiotherapy students and 100 percent response rate. No data loss or absence of response was experienced, since all the distributed questionnaires were completed and returned. This full enough engagement removes the unreliability and representativeness of the research findings.

Public Transport-Related Characteristics of Participants:

Most of them (58.4 percent) stated that they have had difficulties using public transport, and their primary concerns were accessibility, reliability, and overcrowding. Approximately 35.1% has reported that they could not be served at the right time and schedule, which is a sign of infrequent times and long commuting. In general, 57.5 percent rated their commuting experiences as being fair, implying that the discomfort and absence of ergonomic assistance are widespread and could be contributing to the musculoskeletal tension in those who use it frequently. Together, these results highlight the undermined comfort, as well as reliability of a public transport system, which can indirectly lead to musculoskeletal discomfort in the frequent users.

The subsections below elaborate on the level of comfort, transport method, preference to public transport, and proposed improvement which were revealed by the participants.

Comfort Level:

As it can be seen in Table 3, almost half of the participants (48.8%) said that they feel uncomfortable on their way to their destinations, and 12.1% said that they are very uncomfortable. On the contrary, only 35.4% were comfortable. These results demonstrate that a large percentage of the people using the transport services feel uncomfortable on account of traits like crowding, faulty seat installations and the shocking impact of long-lasting exposure to jerks, vibration and this could be a cause of musculoskeletal stress and tiredness.

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Table 3 Comfort Level of Participants During Public Transport Use

COMFORT LEVEL		
	Frequency	Percent
Very comfortable	12	3.7
Comfortable	114	35.4
Uncomfortable	157	48.8
Very uncomfortable	39	12.1

Mode of Public Transport:

The frequency of different modes of public transportation that the participants use is given in table 4 and is further explained in figure 1. Results show that auto-rickshaw was the commonest mode of transport with 35.6 percent of the respondents reporting this mode. The popularity of this mode could be explained by its higher accessibility, versatile paths, and possibility to move in the city congestion, which is why it can be viewed as the appropriate option of short to medium distance transportation. The second most frequent means was the local bus, which was used by 22.3% of the respondents due to its affordable cost and extensive coverage though it is largely identified as facing problems in terms of congestion, lack of space and inconsistency. The red bus service was used by 19.1 percent and this indicates moderate reliance on less organized and relatively comfortable modes of transport systems which could provide better seating position and stability in the ride. Meanwhile, 16.5% of those interviewed had used Chingchi rickshaws, whose feature was low fare and convenience but was usually high in the vibration exposure and little passenger accommodation. A lower percentage (6.5 %) was using mini bus presumably because it was becoming less available or had less route coverage in the city.

Table 4 Distribution of Participants by Mode of Public Transport

Mode of public transport Frequencies			
		Responses	
		N	Percent
Mode of public transport	Local bus use	103	22.30%
	Red bus use	88	19.10%
	Mini buses (University Points) use	30	6.50%
	Chingchi Rikshaws use	76	16.50%

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	Auto- rikshaws use	164	35.60%

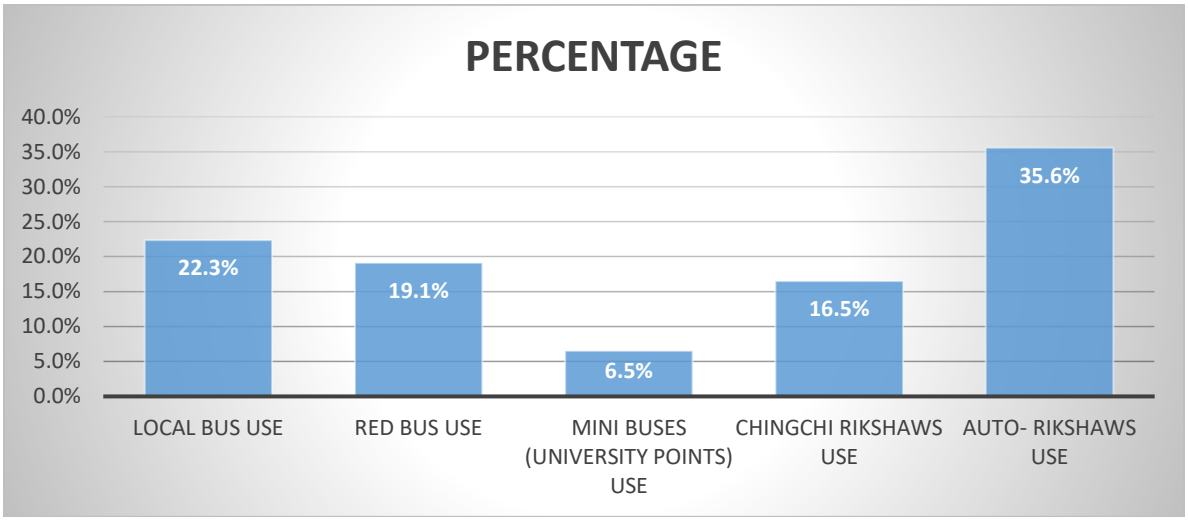

Figure 1 Mode of Transport.

Determinants of Public Transport Preference:

Respondents identified various aspects that determine their use of the public transport as shown in Table 5. Convenience had the highest number with 43.9% respondents citing it as it was due to the convenience, time efficiency, and the suitability of the transport to the students who had a tight timetable. The second most common reason, which was indicated by 27.1 %, was cost, which deals with the economic feasibility of the shared transport. Traffic congestion was cited by 13.1 proportion of the respondent meaning that the use of public transport can prevent delays and stress that comes with heavy traffic. Environmental factors contributed to 9.0% of the sample population implying that they were conscious of the ecological impact, with 5.4% experiencing the lack of parking as a factor that prompted their use of a particular channel of transportation. Only a low percentage (1.5 %) indicated other reasons, indicating that there are other personal or situational factors.

Table 5 Determinants of Public Transport Preference

	Responses	
	N	Percent
Prefer Public Transport because of Cost	126	27.10%
Prefer Public Transport because of Convenience	204	43.90%
Prefer Public Transport because of Environmental concerns	42	9.00%

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Prefer Public Transport because of Traffic	61	13.10%
Prefer Public Transport because of Availability of parking	25	5.40%
Prefer Public Transport because of Other reasons	7	1.50%

Participant Suggested Improvements in Public Transport:

According to Table 6, the most frequent recommendation to enhance the system of public transport was the use of better seating practices (24.4%), as these people were not satisfied with the small and poorly constructed seating which can lead to physical discomfort. The second significant concern was that of safety (23.5%), where the participants needed to mention safe and well-maintained vehicles, a stronger and better control of traffic, and defense against unsafe or harassing conditions. Also, 17.9% would recommend higher frequencies so that overcrowding and delays would be decreased, and 17.8% would recommend that the fares be reduced to make services more affordable to students and low-income commuters. The 16.4% of participants also demonstrated the increasing concern about the cleanliness and sanitation. On the whole, it is possible to infer that commuters prioritize the issues of safety, comfort, price, and cleanliness, which directly affect their health, satisfaction, and desire to use public services.

Table 6 Participant-Suggested Improvements in Public Transport

Participant-Suggested Improvements in Public Transport			
		Responses	
		N	Percent
Improvements in PT	More frequent services-Improvement	118	17.90%
	Lower fares-Improvement	117	17.80%
	Cleaner vehicles-Improvement	108	16.40%
	Safer environments-Improvement	155	23.50%
	Better seating arrangements-Improvement	161	24.40%

2 Descriptive Statistics:

This section presents the descriptive analysis of musculoskeletal symptoms among participants, assessed through the Nordic Musculoskeletal Questionnaire (NMQ). Frequencies and percentages were computed to represent two dimensions of symptom prevalence:

1. Regional prevalence — participants who reported having trouble in specific body regions.

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2. Annual prevalence — participants who experienced musculoskeletal discomfort in those regions within the past 12 months.

It is a better way to describe the symptom distribution globally and gives an opportunity to reflect the musculoskeletal burden of various body parts more accurately.

Table 7 and as further explained in figure 2 reveals that neck (72.4%) and lower back (72.7) were the most affected areas, meaning that the axial areas are most vulnerable to headaches and lower back strain during the use of the transport. Ankle and feet (47.2%), shoulders (44.1) and upper back (44.1) were also often reported, which indicates that both lower and upper extremity are affected by the instability, vibration and a lack of motion related to commuting. A comparatively smaller proportion of participants generated symptoms in the knees (32.3%), hips (27.6%), wrists (27.0%), and elbows (16.8) but they still indicate the cumulative effect of constrained and repetitive postures. In general, these results shed light on the neck and lower back pain as the prevalent among physiotherapy students with the focus on the presence of the poor ergonomics and excessive sitting when traveling.

Table 7 Prevalence of Participants Reporting Trouble in Specific Body Region

REGION	FREQUENCY	PREVALANCE (%)
Neck	233	72.4
Shoulder	142	44.1
Upper Back	142	44.1
Elbow	54	16.8
Wrist	87	27
Lower Back	234	72.7
Hip	89	27.6
Knee	104	32.3
Ankle	152	47.2

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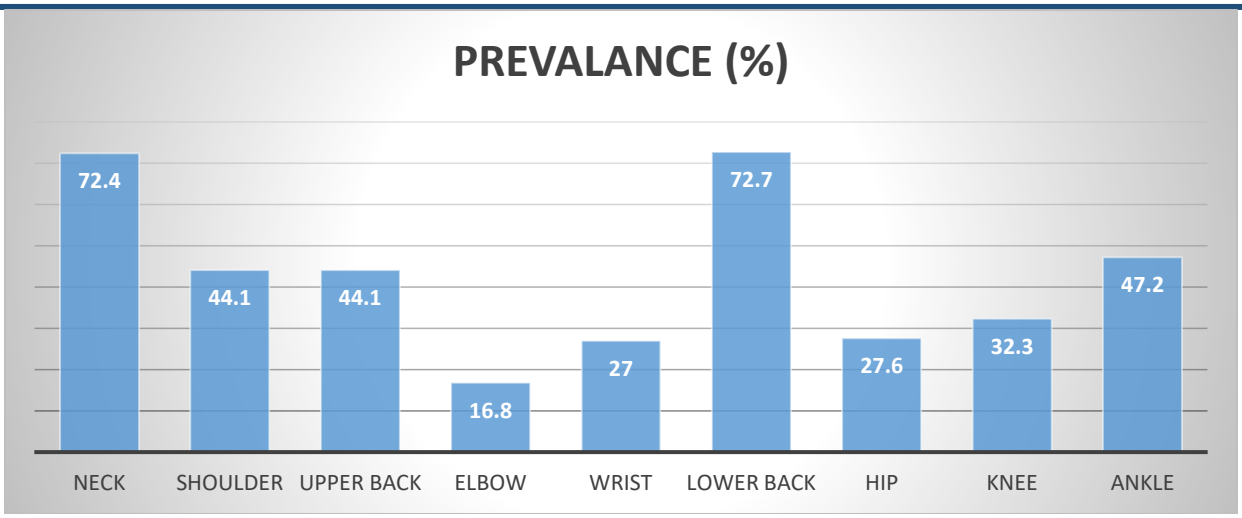

Figure 2 Comparative Distribution of Musculoskeletal Discomfort by Body Region

A very specific but uniform pattern behavior occurred when evaluating musculoskeletal pains occurring over the last 12 months (Table 8) and also demonstrated in Figure 3. The most affected regions were the neck (62.1) and the lower back (58.1) which means that posture-related and weight bearing parts are very susceptible to the strains of sitting in a static and constrained sitting position. The ankles (37.6%), shoulders (33.9%), and upper back (32.3%) were also often complained of discomfort and the knees, hips and wrists were moderately complaining. There is minimum prevalence in the elbow region (10.6%). On the whole, these conclusions imply that commuting-induced musculoskeletal discomfort affects axial and lower extremity areas most, which may be the consequence of inadequate ergonomics of sitting, reduced mobility, and constant exposure to vibration during the commuting.

Table 8 Prevalence of Musculoskeletal Discomfort by Body Region During the Past 12 Months

Trouble Last 12 Months	Frequency	Percentage
Neck	200	62.1
Shoulder	109	33.9
Upper Back	104	32.3
Elbow	34	10.6
Wrist	68	21.1
Lower Back	187	58.1
Hip	70	21.7

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Knee	76	23.6
Ankle	121	37.6

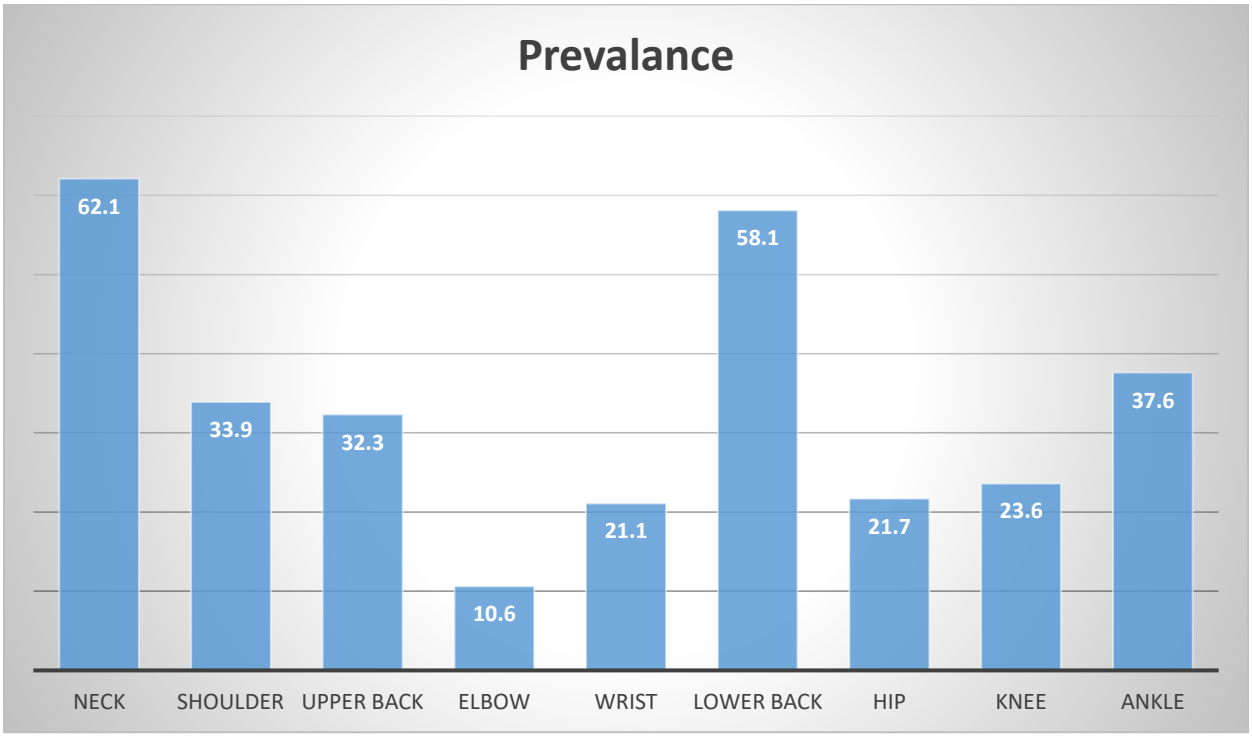

Figure 3 Graphical Representation of Musculoskeletal Discomfort Prevalence by Body Region. (Past 12 Months)

Inferential Statistics (Cross-Sectional Analysis):

This section outlines the inferential analysis that was done to test relations between musculoskeletal discomfort and the chosen demographic and transport-related variables associated with the public transport. The Chi-square test of independence was applied to ascertain the existence of statistically significant associations between occurrence of musculoskeletal symptoms in different body parts and such characteristics of the participants as age, sex, frequency of travels, time spent on the travels and prior experience of the services offered by the public transportation. A p-value below 0.05 was regarded as significant.

Association Between MSDs and Age Group

A definite trend was observed between age group and MSD prevalence as indicated in Table 9. Strong correlations were found in the neck, shoulder, upper back, and hip, ankle region which shows that the more people age the more they become vulnerable to discomfort in these regions defined as possibly due to cumulative academic work load, altered posture or a prolonged exposure to

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transport. Conversely, the elbow, wrist, lower back, and knee did not find any significant relationship with age meaning that it might not considerably contribute to them.

Table 9 Association Between MSDs and Age Group

Body Region	p- Value
Neck	0.04
Shoulder	0.004
Upper Back	0.008
Elbow	0.75
Wrist	0.518
Lower Back	0.368
Hip	0.003
Knee	0.14
Ankle	0.02

Association Between MSDs and Gender

Another observation was exhibited in analyzing the gender-based correlation with musculoskeletal discomfort in various parts of the body as shown in Table 10. Only the area of the shoulder showed significant change, showing that gender could be a relevance to affect pain in the shoulder region, perhaps because the biomechanics of the upper body, the use of the muscles or activity pattern is different in each gender. Conversely, there was no significant relationship of the neck, upper back, elbow, wrist, lower back, hips, knee and ankle areas. This implies that, other than discomfort in the shoulders, there is no significant influence of gender on differences in musculoskeletal symptoms in most of the regions represented in this sample.

Table 10 Association Between MSDs and Gender

Body Region	p- Value
Neck	0.487
Shoulder	0.03
Upper Back	0.53
Elbow	0.57
Wrist	0.516
Lower Back	0.815
Hip	0.09
Knee	0.824
Ankle	0.39

Association Between MSDs and Public Transport Frequency

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Trying to explore the correlation between the frequency of public transport use and musculoskeletal complaints, a small yet significant correlation presented itself in Table 11. There was a high level of correlation in the hip region, thus there is possibility that high frequency of using public transport is the cause of the discomfort on the area, perhaps because people sit on it a lot, are in tight positions, or constantly being strained during the ride. It shows that other than the symptoms that affect hips, musculoskeletal pains in other parts of the body are not seen to be significantly determined by the frequency of use of public transportation among students.

Table 11 Association Between MSDs and Public Transport Frequency

Body Region	p- Value
Neck	0.2
Shoulder	0.2
Upper Back	0.3
Elbow	0.4
Wrist	0.8
Lower Back	0.6
Hip	0.013
Knee	0.412
Ankle	0.119

Association Between MSDs and Public Transport Experience

There was an evident trend seen between the experience of musculoskeletal discomfort in various parts of the body and the experience of public transport as indicated in table 12. The neck, shoulder, wrist, and hip were significantly associated with the exposure meaning that increased exposure to public transport can help develop strain in both the upper and lower body parts. These observations indicate that recurring or prolonged use of the public transport, which often includes and may include crowded conditions, unstable postures and time spent sitting or standing, can impose further biomechanical load on these regions. By comparison, there were no significant correlations between upper back, elbow, lower back, knee, or ankle, which can arguably indicate that pain in these areas can be caused by other factors besides transport experience.

Table 12 Association Between MSDs and Public Transport Experience

Body Region	p- Value
Neck	0.04
Shoulder	0.02
Upper Back	0.76
Elbow	0.06
Wrist	0.02

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Lower Back	0.63
Hip	0.04
Knee	0.91
Ankle	0.77

Spearman's Rho Correlation Between Reported Issues and Body Regions

Positive correlations between experiencing problems and the hip (r = 0.085), ankle (r =0.092), neck (r =0.084), and elbow (r = 0.075) were found using Spearman's rho analysis. The shoulder (r = 0.141, $p < 0.05$) and knee (r = 0.125, $p < 0.05$), showed statistically significant associations. Furthermore, comparably greater levels of statistical significance were shown by the wrist (r = 0.173, $p < 0.01$), low back (r = 0.175, $p < 0.01$), and upper back (r = 0.192, $p < 0.01$) as shown in Table 13.

Table 13 Correlation Between Reported Issues and Body Regions

Body Region	Correlation (rs)	p-value
Hip/Thigh	0.085	0.128
Ankle/Feet	0.092	0.101
Neck	0.084	0.133
Elbow	0.075	0.177
Shoulder	0.141	< 0.05
Knee	0.125	< 0.05
Wrist/Hand	0.173	< 0.01
Low Back	0.175	< 0.01
Upper Back	0.192	< 0.01

Discussion

1. Main Findings

It was found that musculoskeletal disorders (MSDs) were very prevalent among physiotherapy post-graduates of Karachi who commute using the public transportation mode. It is worth noting that 72.7 per cent of the respondents complained of lower back pain, and 72.4 per cent complained of neck pain, followed by shoulders, upper back, and lower limbs. It means that axial and postural areas get affected most and it shows the combined impact of long-standing stagnant position, non-osteopathic seating and having vibration all the time during the commuting. These results align with the findings provided by (11), who also found that the most frequent areas of people who were exposed to prolonged sitting and ergonomics of poor transportation are the neck and lower back.

Public transport seating was described by the participants as hard, uneven, and poorly cushioned, and lack of lumbar or neck support. Most of them said that they were slouching, sitting asymmetrically, or pushing the small space in the vehicle in awkward postures to fit the overcrowding. These changes were probably the cause of long-term lower back pain. There is a protracted increase

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in intradiscal pressure, a decrease in the mobility of the spine, the encouragement of fatigue and microtrauma in the long run (17).

In addition to the lower back, those who had longer commuting periods indicated greater neck and shoulder pain, most likely because of continuous muscular tension to support the head and the upper limbs as the vehicle vibrates or when the user of overhead supports. Such observation indicates that upper body pain is more indicative of dynamic instability and time-dependent exposure, and the lower back pain is mostly caused by the prolonged postural load (35, 36)

The gender -based analysis has shown that discomfort of the neck and upper back was slightly higher among female students than their male counterparts although the statistics were insignificant. This corresponds to the current literature on ergonomic factors that indicate that women could be more prone to musculoskeletal weaknesses because of anatomical distinctions, muscle capacities, and hormonal factors (37). The fact that no significant statistical distinction was high can be attributed to the homogeneity of commuting exposure which supports the control of the environmental factors over personal attributes.

Though lower back pain was common, all its relationships with age, gender, length of travel, and frequency of commuting were not significant, which led to the assumption that the number of risk factors to which participants were exposed was significantly homogenous. The prevalence is high even though the associations are not significant, hence underlining the universality of lower back pain among the student commuters who are experiencing comparable environmental and postural factors. (11)

Qualitative reactions by the participants added more knowledge about psychosocial and environmental aspects of commuting. Despite the fact that the aggregate experience was characterized as a fair response, the results indicated that the students were always unhappy with the seats in terms of comfort, cleanliness and safety. Some of the most recurring ones were overcrowding, bad vehicles, poor maintenance and insufficient ventilation and hygiene including dirty seats and bad smell, made people feel fatigued and generally uncomfortable. These perceptions are in line with the results in studies by (5) and (51), who found cleanliness, comfort, and reliability of the service as the key characteristics of commuter satisfaction and well-being metric.

The issue of safety was acute especially in female participants. In addition to the psychological discomfort, the fear of safety can provoke muscular tension and stress, which indirectly leads to the increase of musculoskeletal pain (50). Some of the interventions proposed by the participants to make commuting conditions better included well cushioned seats with lumbar support, clean and air-conditioned interiors, maintenance of the vehicle, frequency-spacing to reduce congestions, CCTV, better lighting, and providing female passengers with a seat. Others also proposed better road conditions and trainings to the drivers to reduce vibration and sudden movements to a minimum level. Such recommendations are associated with a high degree of awareness of the students about the influence of the infrastructural design on both their physical and psychological comfort, which aligns with the principles of sustainable transport development that focus on the passenger-oriented planning (3, 29).

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In addition, the study participants consisted of psychological fatigue and decreased academic or clinical productivity was attributed to long commutes. Prolonged commuting time resulted in fatigue prior to classes or clinical sessions, which influenced the concentration, manual skills, and cognitive activities. Such observations are consistent with Chen et al. (2024) and Ryu et al. (2025), who emphasized that postural strain and fatigue caused by commuting may be the cause of burnout and poor physical resilience. The gap between knowledge theory and practice is evident between theoretical knowledge and practice since, although physiotherapy students knew about posture and ergonomics, they struggled to use this understanding in the real world based on the environmental factors.

2. Comparison with Literature

The results of this research are to a great extent aligned with the past studies that investigate musculoskeletal health in commuters. A large amount of research has indicated the lower back and neck as the most affected areas since they are subjected to prolonged sitting and whole-body vibrations (34, 38)There were also high-quality results on commuting and lower back pains as reported by (46) but unlike a work environment, where exposure can be significantly different due to specifics of the vehicle type or working schedule, the ergonomic conditions of the students of the study were uniformly poor. This homogeneity probably reduced statistical relationships, although they have high prevalence rates.

These findings find a regional confirmation. Nadeem et al (2024) in Lahore and DPO (2018) in Mumbai indicated the prevalence of neck and back pain among commuter populations, and less significant impact of demographic variables. Similar results were observed by (40) who found that despite the short distance to college, the young student commuters developed a musculoskeletal discomfort as a result of using non-ergonomic vehicles and other psychosocial stressors. These investigations alongside the current study highlight the fact that environmental and infrastructural influences are key factors that contribute to commuter musculoskeletal health, with little impact due to demographic influences.

The correlation between the increased time of traveling and neck or shoulder pain is consistent with the results of Chen et al. (2024) and Ryu et al. (2025) who found upper-body musculoskeletal fatigue to be more responsive to cumulative-time-dependent exposure and postural stress. Some trends, including those related to gender, i.e., some female respondents reported to be somewhat more uncomfortable, yet there are no substantial differences, align with the research conducted by Inayat et al. (2023) and Chowdhury and Van Wee (2020). These papers suggest that although women could be considered both physiologically and socially prone to discomfort, musculoskeletal results are largely dictated by structural factors that include vehicle ergonomics and overcrowding.

The safety issues revealed in this paper align with the previous studies, which show that the risks to female commuters in low- and middle-income economies are skewed in favor of women using public transportation (13, 14). The perceived threats of safety do not merely limit movements but can also indirectly affect the musculoskeletal health by increasing muscular tension and stress (50).

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Lastly, qualitative remarks of the participants about the car cleanliness, level of comfort while sitting in the car, and the overall state of commuting confirm the results of (51) and highlight the significance of service quality and infrastructure in its influence on physical and psychological well-being. In the existing research, there is an original observation: in the groups of people that are subjected to the exposure of the bad commuting circumstances (when the condition of commuting is universal), musculoskeletal uncomfortable may be perceived as a general concept or an outcome instead of a statistically dependent variable. This highlights the need to consider the system-level interventions, such as the ergonomic design of vehicles, frequent repairs, and safety-oriented planning of urban transport, to alleviate the load of MSDs among the student population and other daily commuters (1, 6).

3. Strengths of the Study

Numerous strengths are unified in this research to increase its scientific rigor, contextual considerations and impact on the muscle-related health studies. Its contribution to the local and global discourse on the topic of ergonomics, occupational health, and musculoskeletal welfare is based on the academic suitability of its methodology, the amount of information it offers in the legal context, and the degree of theoretical reasoning. The results of the research are empirically and conceptually clear because of the calculated consistency of the research design to the existing ergonomic, biomechanical and biopsychosocial theories. The sampling, the tool, the method of analysis, were all rationally organized in a manner that portrays validity, reliability and relevancy that accorded academic significance to the study.

The greatest strengths of the research are the big sample size of 322 participants, who were incorporated in the research and are students of physiotherapy and they use the public transport in their daily life. It was a big sample and would have adequate statistical power to reveal any significant trends, relations and correlations between exposures associated with commuting and musculoskeletal health outcomes. The paper explains the dynamic fluctuation which is encountered in an urban scholastic population as compared to smaller research which employs a small or homogenous population. It was the sample that reflected the varying academic years, gender, commuting experience, and it is what allowed understanding the influence of the interaction of the personal and the environmental factors on the musculoskeletal well-being on the fine level.

The other strength is that the research used Nordic Musculoskeletal Questionnaire (NMQ) which is universal and most commonly used musculoskeletal symptom scale. The NMQ design was standardized and in a way that it could capture the data in other regions of the anatomy at the same time hence, intra and inter-study. It is able to measure the extent of the phenomenon, length and effects of musculoskeletal pain in different body parts that enabled a multidimensional assessment of physical strain. This application of a globally standard tool increased its internal validity of the results and allowed it to compare it with regional and international data on MSDs, which placed this study in a larger context of the epidemiology of the world. Moreover, the fact that the NMQ is sensitive to both acute and chronic musculoskeletal diseases was a more specific measure of the

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physical disability of the subjects than a less specific measure. The tool was valid, easy and cross-culturally flexible to ensure the precision of the data and reduced biasness in reporting.

The statistical analysis and strength of methodology also make it a credible study. The significant correlations of demographic and behavioral and exposure-related variables and prevalence of MSDs were monitored with the help of appropriate descriptive and inferential statistics (including chi-square test). This analytical criticality provided empirical plausibility to theoretical assumptions on the premise of the ergonomic and biomechanical principles. In addition, stratified analysis of the variables like age, sex, academic year, time and means of travel; not only made the findings to be statistically valid but also interpretable. Cross-tabulations and prevalence estimates have enabled the adoption of a subtle approach in the process of developing the relationship between commuting-related stressor and academic pressure and personal ergonomic consciousness. Such analysis also demonstrates the methodological correctness of this study as the subsequent research is still in the process of development and is still carrying out such deep analysis in various working and educational environments.

Among the relatively limited strengths of the study that can be singled out, one can point to its contextual and societal value since it is interested in the musculoskeletal health in the context of a specific socio-environmental environment Karachi. The Karachi congestion, the infrastructure and use of the public transport system predispose the environment in which most of the daily commuters in Karachi are exposed to poor ergonomics, postural stress and vibration is inevitable in Karachi. This kind of research involvement in such a real-life setting will help take the research out of pure theoretical conjecture and present grounded information with evidence backing on an issue that is slowly becoming increasingly important to the health of the population. The fact that MSDs occur in such an environment not only speaks of the inefficiency of the public transport systems in terms of ergonomics, but also of the health status of the low- and middle-income cities in general. The local taste will offer the opportunity to design the regional preventive actions not only as the element of the national health promotion campaign but also as the valuable addition to the global discourse of the issue of occupational health inequalities in the developing countries.

Moreover, the fact that the proposed study will include physiotherapy students as the respondents will introduce a new comparative dimension of the study, which will support the conceptual framework to an impressive degree. The special population in physiotherapy is that the students possess a combination of theoretical knowledge of musculoskeletal functioning and a clinical task exposing them to physically demanding activities and commutes to school. This knowledge and vulnerability fact leads to the fact that the two forms of a paradox are inter-weaved and that the further study will be richer in the analysis because even though these students will be given posture, training in biomechanics and injury prevention, they will still be vulnerable to the strain of the musculoskeletal system by external environmental factors that are external to them. It is a theoretical-practical part of the study, which proves the absence of correlation between the knowledge of ergonomics and its application to a practical case. The findings, therefore, are not just a reflection of a population at risk but the data needed by the curriculum development in the area of

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physiotherapy education to make the educators consider the inclusion of the ergonomic self-care and applied body mechanics in the curriculum.

The other strength is that the study is ethical and the principles of research ethics are followed. Informed consent and autonomy were also made available since the subjects were well informed on the objectives of the research, procedures and voluntariness of the research. The privacy of the participants and the improvement of the ethical validity of the research process was guaranteed by the fact that the responses were considered to be confidential in the data collection and analysis. In addition, the method used in the study is understandable thus replicable which is among the principles of academic honesty. This fact is both ethically and procedurally true, which contributes to the information being more realistic and the research being more promising to be utilized as an example of the further research in the same conditions of education and work.

The study has intellectual strength of inter-disciplinary application of theoretical frameworks that are founded on the biomechanical, ergonomic and biopsychosocial theories. This study can be viewed as an attempt to integrate two or more paradigms in explaining the occurrence of muscle skeletal disorder in a holistic approach among the physiotherapy students who use transport system to get to their school. Environmental design and psychosocial aspects are never researched in vacuums but as a phenomenon that is self-related and expands the research breadth interpretive. The multidimensional approach will enable the study to produce results that can be generalized to the students of physiotherapy not only to the other segments of the population who also have to withstand the same degree of commuting related stresses as office workers, health care practitioners and other occupationally physically active groups as well.

The overall scientific approach justifies the translation of the information presented in the research paper because it shows how the facts are interrelated with the work recommendations. Its results would be established to provide healthcare instructors, ergonomists and policymakers with information on the dread of the job of the occupation in the new setting as regards the students and commuters. The translational potential is what transforms the research into a straightforward academic process to a social and institutional enhancement. The study is the basis of preventive interventions like postural awareness training, transportation system redesigning and integration of muscle skeletal wellness unit in physiotherapy. These implications show the practical usefulness of the study and the impact it will have on the evidence-based practice and policy sphere.

Lastly, the strength of this study is another aspect because it will be possible to continue and expand in the future. The research provides a foundation upon which longitudinal or interventional research conducted on the prevention of MSDs can be performed in order to assess such measures by setting a baseline level of prevalence compliance and contributing factors of MSDs among physiotherapy students at Karachi. Further studies can expand on this study to investigate whether ergonomic adjustments, special exercises, or education can work to decrease musculoskeletal risk.

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4. Limitations of the Study

Despite the fact that the study offers valuable information in relation to musculoskeletal health among students in physiotherapy using the transit, some limitations should be considered in order to know the significance of the research.

To start with, the cross-sectional research design of the study limits the possibility of concluding the cause and effect relationships. Since the data were observed at one occasion only, it cannot be known whether the time-exposure to the conditions of the common transport caused the development of musculoskeletal disorders (MSDs) or it was the underlying symptoms that impacted on commuting among students. Longitudinal study would be more suitable in order to monitor the evolution and growth of MSDs with time.

Second, the sample was mainly composed of female students in the physiotherapy department since there are relatively smaller numbers of male students enrolled in the program, and even those who took public transport. This gender asymmetry can be a constraint to the generalizability of the results to male students.

Third, the research made use of pure self- reporting using the Nordic Musculoskeletal Questionnaire (NMQ). Self-reported data is prone to recall error, being under/overreported and difference in individual perceptions of pain. Theoretical knowledge of physiotherapy students of posture and ergonomics might also influence the responses of the latter, even in a subtle way. More objective testing would be necessary like a form of clinical assessment, posture analysis or even ergonomic testing giving more accurate reliable data.

Fourth, the study lacked a geographical area and demography. All subjects were selected in Karachi, which is one of the cities in Pakistan that has heavy traffic, disorganized transport systems, and difficult commuting conditions. This gives a significant background but the research cannot be applied to students in cities with better infrastructure or other cultural settings. External validity would be enhanced through broader sampling in various cities or institutions.

In addition, the study was unable to completely measure significant confounding variables that could affect musculoskeletal wellbeing. Other variables that were not studied in detail include physical activity levels, past injuries, ergonomic habits associated to the studies, academic stress, sleep quality and lifestyle factors. These immeasurable factors might have induced the observed associations and may also be the sources of variations in the prevalence of MSDs to some degree.

Besides that, there were pragmatic issues that influenced the intensity of the study. Scholastic timelines acted as constraints to the research since more extensive data collection or subsequent interviews were not possible due to the limited period needed to complete the research on the books of the author. Lack of logistical processes like ensuring the accessibility of the participants in the various regions of Karachi at the height of traffic also limited the process of data collection.

To sum up, though the given study contains some valuable evidence on MSDs among physiotherapy students who travel by transport, the study design, application of self-reporting, short time span, limited resources, and contextual constraints show that it is necessary to conduct more

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comprehensive, longitudinal, and multi-centered studies to reinforce the given results and improve upon them.

5. Implications for Physiotherapy Practice

The research results have profound complex implications on the physiotherapy practice since they reveal that musculoskeletal disorders (MSDs) need preventive and treatment measures in a wide population. The physiotherapists are more likely to detect the musculoskeletal pain at its initial stages even when the pain is mild or intermittent which is important in preventing the escalation of the acute or minor complaints to chronic and debilitating disorders. Such a premature diagnosis would be possible by subjecting the At-Risk people to a systematic and regular screening procedure with the help of standard and valid assessment tools, e.g. Nordic Musculoskeletal Questionnaire (NMQ). These tools are not only useful to identify the symptoms in various areas of the anatomy appropriately, but also to compare the findings with the already existing research and improve the evidence-based practice.

Preventive education is the other significant element of physiotherapy intervention. The physiotherapists are to be trained on the right posture, body mechanics and ergonomics depending on the needs of the students, office workers and daily commuters who are constantly at risk of prolonged sitting, awkward poses and repetitive injuries and strains. This training may involve demonstrations, drills and personal recommendations on how to support spinal positions, best workstation and sitting position and application of safe lifting or carrying methods. What is more intimidating about these preventive measures is the ambience that is created in the urban setting with low infrastructure and in which it might take several hours to get to the destination such as Karachi where the traditional burden of daily travelling can worsen the musculoskeletal pain symptoms.

Besides the educational programs, physiotherapists would also have a chance to design and prescribe some exercises programs which would cover the most problematic musculoskeletal regions, which are neck, shoulders, upper back, lower back, and wrists. These programs may involve strengthening exercises to enhance the condition of postural stability and defined core muscle sustainability, stretching exercises to de-tense tight muscles, mobility exercises to retain the range of motion of the joints, and explicit conditioning exercises to enhance the overall musculoskeletal endurance. The low-charge workout that might be implemented during the breaks, during the waiting in a transport, or during the study periods between both students and commuters might lead to the tremendous decrease of the musculoskeletal loads and increase of the functional capacity in the long-term.

The hypothesis is that early intervention based on the occupational physiotherapy, active stretching exercises and posture training with the assistance of dynamic poses can considerably decrease the level of muscular tension that builds up when sitting in a particular position during a long sitting or during the way to work. The inclusion of region-specific stretching can be not only applied to provide flexibility by incorporating such stretching as upper trapezius stretch, levator scapulae stretch, which alleviates neck pain, pectoralis minor stretch, which may be used to treat rounded shoulders, and

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hamstring and piriformis stretch, which may be used to treat lower back pain and forearm pain respectively. In the same manner, the exercises performed to enhance the utilization of the postural stabilizers such as the deep cervical flexors, scapular retractors and the core muscles should be reinforced to provide endurance and positioning of the spine during the transit in the day-to-day activities. Thoughtful use of thermotherapy and cryotherapy may also be made to beautiful treatment of the symptoms: the damp heat may be used to loosen the spasms of the lumbar or cervical area, the cold treatment of the acute inflammation of the overworked joints or tendons.

The other aspect of intervention is lifestyle change. Physiotherapists may also use the opportunity to educate people about the necessity of including regular micro-breaks, commuting to work by means of active commuting (Walking or biking where possible) and stress-relieving practices that put the mind in the ground into their everyday routine. Such factors as chronic stress and sedentary behavior are regarded as the causes of musculoskeletal discomfort and the holistic approach to the problem can decrease the risk of developing MSDs because of the cascade of factors. Moreover, the physiotherapists would have the capacity to implement structural changes in the schools and transportation like ergonomic seats, supportive furniture and mobility and breaks policies, which would not be out of line with intervention should be applied at the individual level.

In addition to it, exercise alerts on mobile phones, posture monitors, and resistance belts that can be used during the traveling can be encouraged to ensure that students actively manage their musculoskeletal issues with the assistance of physiotherapists. This would be integrated in prevention of exercise and ergonomics awareness programs in college wellness programs or institutional physiotherapy departments in the long run. On a more radical level, one may have the implicit collaboration of physiotherapists, urban planners and transport authorities to develop ergonomic high-quality seating, adjustable headrests and vibration dampening bus seat cushions, which would be more effective to remove the biomechanical load during transit. The physiotherapy curriculum should also be adjusted to incorporate the courses of urban ergonomics/occupational biomechanics and transport-related MSD prevention and provide the future practitioner with the chance to be exposed to the scientific knowledge and skills to meet the new demands of the population health. Lastly, the results would be representative of preventive, holistic physiotherapy model, which would not be grounded on treatment rooms, but on other socializing places, learning institutions and policy models to guarantee long term musculoskeletal health and strength of an urbanized society such as Karachi.

These interventions should be incorporated in the practice of clinics as well as teaching the young adults with an aim of instilling a culture of musculoskeletal health in them especially the high-risk groups who might be influenced by their school work, commutes or workloads. The prevalence of MSDs can be decreased, and the tendencies of their severity can be reversed, which is possible, and the overall functional capacity, the quality of life, and the long-term musculoskeletal conditions can be improved by physiotherapists through early identification, prevention education, specially designed exercise programs, and lifestyle change. This makes the physiotherapy practice an extension of the reactive treatment to the proactive and preventive treatment that equips the individuals with

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the knowledge, skills and behaviors that are required to ensure musculoskeletal well-being throughout the lifespan. Moreover, the holistic approaches have wider implications on the community health in the sense of influencing the policy making, urban design and occupational ergonomics in a systematic manner that musculoskeletal health is considered in a systematic manner at individual and community level. Lastly, the results show the overall importance of the physiotherapists in enhancing sustainable musculoskeletal health, less disability, and good physical functioning among the population with chronic postural and environmental pains combined.

6. Recommendations for future work

Resting on the findings and limitations adopted during the study process, it is possible to give some general recommendations on how future research in the musculoskeletal health area can be conducted among physiotherapy students and urban commuters. Although, the current research is thereby useful in cross-sectional observations of the prevalence and the lack of causal aspects of musculoskeletal disorders (MSDs), the nature of the study will automatically curb the inferences. Consequently, longitudinal research should be highly advised to monitor dynamic musculoskeletal health changes over time which would enable the researcher to determine causal relationships among the most important variables and include the travel time, postural behavior, academic workload, clinical training exposure, and lifestyle behaviors. These studies would give a better insight into the role of repetitive exposure to particular risk factors in the development, evolution, or elimination of musculoskeletal complaints and would eventually guide preventive measures and policy interventions.

An important recommendation of future research is also to conduct the assessment of specific ergonomic interventions and preventive exercise programs. Although this paper has shown the relationship between the long sitting, bad postures, and MSDs, there is scant empirical data on the impact of organized interventions on its occurrence among similar populations in an urban setting such as Karachi. The experimental or quasi-experimental designs may study whether the ergonomic education, posture correction programs, and strengthening exercises or stretching exercises can play a significant role in diminishing the prevalence, severity, or recurrence of MSDs. Also, the research on the most efficient time, frequency, and kind of exercises might be investigated to achieve the best outcomes, and whether such programs would be equally helpful with students, commuters, and other occupational groups.

The other most important recommendation is to increase the geographical and demographic coverage of the future studies. Though this study was restricted to Karachi, a big, congested city surrounded by low infrastructure among other aspects where people depend heavily on the public transport mode, other cities or areas with different urbanized structures, transport systems, and culture would enhance external validity of the results. The musculoskeletal health may also be compared across populations that have different socioeconomic statuses, professional activities and lifestyles, and may help to understand the risk factors depending on specific contexts. Universal risk

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factors and interventions could be detected by comparing across cultures, and specific issues of the population might be detected and need specific solutions.

Objective assessment measure and self-reported data should also be incorporated in future research. Although Nordic Musculoskeletal Questionnaire (NMQ) is a reliable and common method, self-reporting may be associated with the presence of recall bias or subjectivity of the perceived symptoms. A combination of objective assessments, like posture analysis using motion capture technology, wearable activity tracker to determine the amount of sedentary behavior and level of physical activity, clinical examination of musculoskeletal functionality, and even imaging research would be a more reliable and thorough dataset. These multidimensional measures of assessment would also increase the accuracy of the results and enable the researchers to consider the weak relationship that exists between self-reported discomfort and the measurable body variables.

In addition, he or she would be keen on exploring the psychosocial determinants and lifestyle of musculoskeletal disorders. Known to interact with musculoskeletal health are stress, mental workload, sleep quality, nutrition and a level of physical activity but the current study did not capture these factors altogether. Validated tools to measure the level of stress, mental health situation, and behavioral patterns could be used in the future research to give a complex picture of all the combinations of psychological, social, and physical factors contributing to MSDs. These interactions could be used to understand integrated intervention strategies that can adequately consider the physical, behavioral, as well as the psychosocial aspects of musculoskeletal health.

Lastly, future research can concentrate on long-term effects and follow-up to give evidence on the chronicity, recurrence, and functional outcomes of musculoskeletal disorders in the long-run. The benefit of observing subjects not in a cross-sectional study is that researchers can determine the intervention response, the inherent progression of musculoskeletal disorders as well as the long-term advantages of preventive training and ergonomic modifications. These insights would be especially useful in physiotherapy education and in planning of the public health since they would offer evidence-based directions on how to design sustainable measures in order to lower this burden of MSDs in both student groups and in urban commuters.

To conclude, further studies would prefer following the longitudinal, multi-centered, and mixed-method designs, combining the subjective, objective ratings, and taking into account the psychosocial and lifestyle aspects. Such researches would give a stronger, holistic, and practical insight of musculoskeletal health, which ultimately would help in informing preventive measures, clinical practice interventions, and policy formulation that would greatly decrease morbidity and epidemiology rates of MSDs in at-risk groups.

CONCLUSION:

The paper offers a many sided and inclusive insight of prevalence, occurrence, and causes of musculoskeletal disorders (MSDs) among physiotherapy students in Karachi with special focus on

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physical and environmental requirements of using public transport. The results show that there is a high incidence of musculoskeletal pain which is mostly at the neck, shoulders, upper back, and lower back regions which are important in ensuring the maintenance of spinal position, mechanical stability, and effective position of the posture. These findings demonstrate that the threat of musculoskeletal strain is high even in a young health-literate group of patients, like physiotherapy students, in case of being exposed to environmental and ergonomic stress factors on a chronic and inescapable basis.

Analytically, this paper undermines the traditional perspective that MSDs only affect older people or those that have uncharacterized and demanding jobs. Instead, it proves that Musculoskeletal strain is an urban result of modified urban life and entails long periods of stationary roles, poorly designed ergonomic setting, and monotonic weight-bearing. Physiotherapy students, although aware of body mechanisms and postural adjustment, constitute a group of people whose knowledge is not enough to overcome the external mechanical mechanisms. The protracted periods of academic work, clinical practice, and daily travel to and from work on the bus/train are added up to form the ongoing cycle of stress, burnout, and lack of musculoskeletal rest.

The challenges are aggravated by Karachi being a thickly populated urban area. The public transportation system of the city, which is frequently congested, in poor conditions, and non-ergonomic, is the cause of constant biomechanical stress. The constant vehicular vibration, sudden jerks, braking, and mechanical repeated shocks, often are a regular experience of the passengers due to inconsistent roads and the lack of proper suspension systems. Such mechanical disturbances subject the commuters to uncomfortable and cramped positions in the long-run. The vulnerability of the risk to spinal loading is also augmented by the absence of lumbar or cervical support, legroom or unstable seats. They interfere with the physiological muscular activity, impairment of blood circulation and acceleration of fatigability especially of lower back, shoulders and neck. These accumulations of traumas over the years provide muscle skeletal pain and structural imbalance on the long-term basis.

Besides these physical strains, there are also academic strains that accelerate the same even more. Physiotherapy education involves prolonged periods of sitting in form of lectures, laboratory sessions and clinical rotations mostly in non-ergonomic chairs. Sustained sitting, flexion of the spine and confined sitting positions decrease muscular endurance and destabilize the spinal system. Besides, the mechanical stress of the cervical and upper thoracic areas is added to the habitual use of handheld electronic device during travels and studies, which is performed with a bending of the neck and the formation of rounded shoulders. Musculoskeletal loading can also be exacerbated by the habitual carrying of heavy backpacks full of books, laptops, and clinical equipment, during which the muscle loading is also asymmetric. The little possibility of stretching or postural balance (including posture) and the lack of rest between commuting and academic activities have a combined action that sustains the fatigue and mechanical load. Combined with these exposures, the occupational-like risk factors are simulated, and it should be highlighted that even at the professional training early stages, musculoskeletal disorders may develop.

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Though the physiotherapy students theoretically have the knowledge of ergonomics, they are exposed to psychosocial demands of academic demands, clinical performance expectation and time demands on a daily basis and this may lead to muscle tension, pain intolerance and increase the postural fatigue. These psychosocial aspects of the body combine with biomechanical stresses enhancing perception and escalation of pain. As a result, musculoskeletal health is a complex manifestation of physical, emotional, and situational health but not a completely physiological process.

Moreover, this study highlights the importance of urban ergonomics, i.e. the overall impact of the design of the city, transport and education facilities on human musculoskeletal health. The use of non-standardized means of transport, the lack of ergonomic control, and the lack of population health awareness add to the possibility of MSDs on the population level in Karachi. In the case of physiotherapy students, it is quite paradoxical that those who are supposed to be trained to advocate physical health are the people who are undermined by the same environmental systems that they have to traverse regularly in life. This fact explains why there is urgent need to have an urban health system that incorporates the concept of ergonomics in the design of public transport, institutional seating layout, and urban planning.

Beyond local implications, the findings help with a larger worldwide debate on the rising burden of musculoskeletal disorders among the young adults. In the developing and industrialized world, there is a transformation in the epidemiology of MSDs due to sedentary academic schedules, addiction to the digital world, and limited commuting options. This study is consistent with the global findings which suggests that exposure to mechanical strain in the early part of the adolescence stage and unhealthy posture in youth and early adulthood make individuals susceptible to developing chronic musculoskeletal complications in future life. The early intervention of these risks, namely, prevention measures in schools, may, thus, yield lasting outcomes to employee productivity, medical expenses, and life quality.

Critically, the present study is a valuable addition in terms of the characteristics of the learners and potential future providers of healthcare through the analysis of physiotherapy students. Their duality increases the significance of transforming the ergonomic theory into lived practice. The continuity of MSDs even when people have theoretical knowledge implies that there is a discontinuity between the cognitive perception and behavioral actions. This gap can be closed by integrating preventive ergonomics, active way of applying correction posture and musculoskeletal self-care in the curricula of physiotherapy. Professionals developed through the focus of self-awareness, regular exercise and environmental adaptation are not only clinically competent, they can also be personally resilient to physical stress. Such congruence between education and self-directed health practice also can lead to development of empathy, because when physiotherapists are familiar with discomfort themselves, they would be more capable of creating interventions targeted at the patients.

The implication of this study is to the healthcare educators, administrators, and policymakers. As a teacher, the results indicate the necessity of including the ergonomic evaluation and self-reporting techniques in the educational setting. To policymakers, the evidence highlights that it is necessary

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to enhance the ergonomics of the public transport; to that end, better seating designs and shock-absorbing technologies and safer commuting infrastructure are necessary. In the case of healthcare facilities, wellness programs and ergonomic audits can ensure that the risks suffered by both the students and the professionals are alleviated. One way to improve sustainable musculoskeletal health among academic and urban populations is through collaborative musculoskeletal health efforts across sectors; such as health, education and transportation.

The research paper summarizes the current literature on the prevalence and the causal factors of musculoskeletal disorders and expands the sample aspect to the setting reality of the city, lifestyles, and levels of professional health training. It shows that musculoskeletal well-being is a complex construct which is informed by mechanical exposures, environmental conditions, psychosocial demands, and adaptive behaviors. The finding of these interrelationships assists the study to present a basis of comprehensive preventive models that embrace ergonomics, lifestyle change and a social health policy.

Finally, the results may be employed to demonstrate that the musculoskeletal issues of the physiotherapy students are not the individual cases but the manifestations of the systemic issues in the learning and urban settings. The accretion of biomechanical overload, which is a threat to the spinal and postures in the long term, is caused by monotonous movements of the cars, acute movements, and limited postures, academic stress and computer addiction. The cycle is also supplemented by these microaggressions and exhaustion of using the handheld device on a regular basis, having to carry gigantic packs in the backpack, and lack of postural variation. Nevertheless, they are the same challenges that can be transformed as well. The healthcare educators and policymakers can contribute to the generation of physiotherapists that is not only based on their technical knowledge but has an experience of the relationship between the human and the environment. These professionals will popularize prevention health and efficient physical performance which cannot be short-term but must be included in the list of theoretical application and practice. Through this, the study helps in the actualization of an enlightened, evidence-based and holistic physiotherapy education and practice based on the holistic promotion of musculoskeletal health on individual, institutional and societal levels.

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