ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jan146

Biomechanical and Musculoskeletal Disorders in E-Sports Player: An Integrative Review of Literature

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Publication Date: 2026/01/09

Abstract: The e-sports world is rapidly professionalizing, creating a highly risky performance environment concerning long hours of static posture, intense and repetitive movements of the upper limbs, and sustained visual and cognitive loads. The biomechanical stresses are leading to a high prevalence of musculoskeletal diseases amongst e-sports athletes. Training regimes for these athletes span from 5 to 12 hours with a myriad of exposures causing serious risks for their cervical, thoracic, lumbar spine and upper extremities due to bad ergonomics, lack of variability of movements, and sustained flexed postures. Such worldwide participation is on the rise but there exists scant evidence synthesis of the biomechanical and musculoskeletal implications of e-sports, especially concerning injury mechanisms and preventive intervention avenues.

- ***Aims:***
  The aim of this integrative literature review is to identify, synthesize and critically analyse the current evidence analysing the biomechanical risk factors, musculoskeletal disorders, and intervention strategies resulting from esports participation.

- ***Design:***
  Integrative literature review.

- ***Methods:***
  A thorough search system of the peer-reviewed primary studies was conducted across electronic databases. Participating studies had to involve e-sport athletes and provide biomechanical, postural, ergonomic, or muscular outcomes. Data were then extracted and appraised using the Crowe Critical Appraisal Tool (CCAT) before being grouped thematically, following Burnard's (2011) content analysis framework.

- ***Results:***
  Nine different primary studies met the eligibility criteria. In studies with cross-sectional and experimental designs, a high prevalence of musculoskeletal disorders was noted, with neck, shoulder, upper back, lumbar spine, wrist, and hand regions being the most affected. Most significant contributors to biomechanics were prolonged gaming hours, maladaptive postures including forward head posture and thoracic kyphosis, decreased craniovertebral angle, poor screen ergonomics, and high levels of digital engagement or even gaming addiction. While research does not correlate forward head posture to MSDs, almost all have emphasized the cumulative effect of static loading and repetitive movement. Intervention studies indicate that ergonomic training coupled with physical exercise has produced positive outcomes.

- ***Conclusion:***
  Musculoskeletal disorders among e-sports athletes are not rare, seemingly associated with modifiable biomechanical and ergonomic factors. The evidence supports a multiple-hurdle approach toward the active prevention of MSD: workstation optimization, postural corrections, load management, and physiotherapist-supervised exercise interventions. This finding is reshaping clinical inspection, athlete management, and injury prevention within the burgeoning field of esports.

Keywords: *E-Sports; Musculoskeletal Disorders; Ergonomics; Biomechanics; Posture; Gaming Sports.*

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jan146

How to Cite: Dr. Harsirjan Kaur; Dr. Jaganjyoti Das; Ayushi (2026) Biomechanical and Musculoskeletal Disorders in E-Sports Player: An Integrative Review of Literature. *International Journal of Innovative Science and Research Technology*, 11(1), 257-268. https://doi.org/10.38124/ijisrt/26jan146

I. INTRODUCTION

Musculoskeletal disorders (MSDs) are disorders that affect the largest chunk of the population in healthy life all over the world and which just now begin to cause trouble in those occupations having similar threads of work such as repetitive movements, static posture for longer times and high cognitive load. While many decades have gone by for the traditional, labour-intensive professions, the new age digital industries like esports, are slowly making their foray into claiming a part of this pie. From being an informal recreational gaming activity, the esports domain has evolved to be highly formalised into a competitive performance space, along with commercial options, professional leagues, world tournaments, and structured training systems. Further specialization in competitive gaming now brings more biomechanical and physiological load onto athletes by developing the overuse injuries with its physical deprivations.

Esports athletes are primarily distinguished from the other group based on performance criteria. Fine-motor control, reaction speed, visual tracking, and sustained cognitive input are the pillars of all performance indices in this realm. Much like all the other groups, they require high training volumes, great consistency in performance, and some physical prep to resist repetitive loads. On the other end of the spectrum, sports performance is mostly seated posture for extended periods, added to eccentric upper-extremity repetitive movements. On the other hand, the esports environment finds more relevance in scouting-free finger-wrist and forearm movement, up to hundreds of such movements per minute. Cumulative stress placed on body tissues through neurophysiological fatigue and hence initiation of MSDs through repeated patterns of movement maintaining their relative knee, shoulder, and trunk muscles is an injury risk.

Very high prevalence rates concerning neck, shoulder, upper back, wrist, and hand problems are reported in several studies conducted on the esports population. Long gazes at the computer screen demand cognitive powers and aggravate injury from poorly aligned ergonomic postures accompanied by inapt physical conditioning. These are problematic factors triggering pain and functional impairment: forward head posture (FHP), functional craniovertebral angle (FCA), thoracic kyphosis, and repetitive deviations of the wrist. Injury risks are known; however, the establishment of injury surveillance systems and evidence-based preventive paradigms in esports have yet to catch up to those in traditional sports.

As an emerging sporting discipline, the arrival of esports makes the recognition of biomechanical stressors in the high-level gaming context very pertinent to physiotherapists, medicine professionals, and ergonomists alike. When they are not continuously training up to eight hours and travelling to events and performances during the esports season, they continuously pile weights upon their bodies with chronic musculoskeletal stress loads that point to damage making candidates optimal for disabling conditions and shorter careers. Hence, an extremely important issue has to deal with the biomechanical mechanisms underlying these injuries in order to design appropriate interventions for athlete health promotion and performance optimization.

This includes background risks, prevalence, and the separate treatment into various studies, which sounds like it would really best be integrated through a comprehensive synthesis putting together all the biomechanical evidence with clinical MSDs related to esports athletes. Most prior reviews have mostly addressed the general gamer population, or psychological issues, with scant literature addressing physiotherapy and biomechanical dimensions of MSDs in esports.

Thus, this integrative literature consideration will fill this gap by integrating recent knowledge on biomechanical and musculoskeletal effects of esports participation. The review will cover injury patterns, mechanical stressors, ergonomic contributors, and possible interventions. In an integrative framework involving all methodologies, this review modes-built multiside dimension much into the multifactorial nature of MSDs in esports athletes, on top of the evidence presented for guiding the way for prevention and treatment as well as for future research direction.

II. BACKGROUND

A. Evolution and Definition of E-Sports

Competitive videogaming today, or "esports", can be in many forms: from amateur, semi-professional or professional. In just under ten years, what started as an occasional past time has grown into an extremely competitive and fast-evolving reality with a healthy, global sport ecosystem. Tournaments, professional teams for hire and good leagues have been established, even instituting systems of sport science support notably similar to its more popular counterparts. Like any sport, esports athletes endure the same whole training schedule and same dedication; they can work out, at most, from six to twelve hours a day using a multitude of activities such as gameplay, strategy development, communication drills, and refining mechanical skills.

The e-sports industry has a multitude of genres that classify into multiplayer online battle arena (MOBA), first-person shooter (FPS), real-time strategy (RTS), sports simulation, and mobile e-sports. Each of these games has its own unique gameplay requirements, but the common denominator among them is the rapid-fire motor response that needs to be delivered, the speed of visual-motor coordination, tactical cognition, and precise neuronal

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jan146

control. In addition, as the discipline matures, the performance standards expected of sports in the e-sports community have also increased. Although non-contact sports, e-sports is a sitting sport; the physical and psychological load on individuals in this category is raised. They all rouse fine-motor actions, repetitive and similar to activities of high-skill precision-associated sports, like archery, shooting, and table tennis.

Having progressed as a profession, esports organizations have emerged and started to establish their program of coaching, strength and conditioning, and nutritional support as well as mental training into their organizations. On the other hand, musculoskeletal health within esports as a new athletic paradigm has been little researched, which is a significant gap in light of emerging evidence connecting esports participation with conditions like chronic pain, postural abnormality, and long-term functional impairments.

B. Biomechanical Demands of Esports Performance

Biomechanical demands for esports are unique and specific to require static postural loading with both rapid and high-frequency distal motor activity, unlike traditional sports missions which are made up of dynamic multi-joint movements and activation of large muscle mass.

➢ *Fine Motor Control*

The player performs very fast continuous finger, wrist, and forearm movements, such as clicking, tapping, swiping, or pressing keyboard keys. Reports show that elite gamers can perform 300 to 600 actions per minute (APM), producing repetitive mechanical stress on tendons, ligaments, and neuromuscular structures of the upper extremity.

➢ *Sustained Static Posture*

Normally static posture while playing also requires a person's body to require staying seated in such a way as to have the upper torso lean forward and both flex the cervical spine and protract the shoulders. Increased static postural loading causes increased fatigue in its postural muscles, such as:

- Cervical Extensors
- Upper Trapezius
- Levator Scapulae
- Thoracic Erector Spinae
- Forearm Flexors/Extensors

Sitting without much dynamism for long sessions leads to creep deformation, which shortens passive structures while stabilizing musculature less activated.

➢ *High Cognitive Demands*

Simultaneous tracking of visual-spatial information, tactical decisions made rapidly by reaction time, very fast processing of memory, and continuous attention constitute the cognitive requirements for esports. These aspects elevate the level of sympathetic activity and increase co-contraction patterns at the neck and shoulder muscles, thus causing the occurrence of muscle tension and ischemia.

➢ *Visual Strain and Oculomotor Load*

Players gaze for hours at a time holding in a certain visual focus. This fixated gaze and distance from a screen coupled with insufficient light creates influences on head posture, with an increase in forward head position and craniovertebral angle deviations.

These properties of biomechanical demands act, causing tissue overload, neuromuscular imbalance, and aberrant movement patterns that render athletes prone to musculoskeletal injury.

C. Prevalence of Musculoskeletal Disorders in Esports Athletes

It is most interesting to note that although there seems to be very little study on the prevalence of MSD in various populations participating in different esports, studies on different population figures have revealed high MSDs across the spectrum, with the pre-eminently high part of the body being in the neck, shoulders, upper back, lower back, and wrist and hand.

Study evidence contained in this review reveals that this consists of a prevalence of neck pain ranging from 40-60%; shoulder and upper back discomfort affecting 30-50%; lumbar spine pain affecting up to 29%; and especially common wrist and hand strain among mobile esports athletes. Other secondary complaints are sleep disturbance and fatigue.

This relationship is strong between the long hours of gaming and the MSDs that develop as a result. Research shows that more than 5-10 hours of training contributes to the increased severity of pain, functional disability, and postural deviation. Additionally, an early-onslaught of pain has been reported among players with only 12 to 24 months of experience in esports, indicating that MSD development is rapid and accumulative.

D. Postural and Ergonomic Risk Factors

Musculoskeletal health in esports athletes is very much dependent on their posture. Some posture-related risk factors were identified:

➢ *Forward Head Posture (FHP)*

It's a forward translation of the head on the trunk to reduce the craniovertebral angle. There will be increased compressive forces on the following: cervical vertebrae, intervertebral discs, and facet joints; and soft tissue of the posterior cervical region. This is a posture developed by ESports players mostly if they're leaning to the screens, especially under competitive or high-focus conditions.

➢ *Rounded Shoulders and Thoracic Kyphosis*

Static seated gaming increases thoracic flexion and scapular protraction which;

- Reduces shoulder girdle stability
- Increases strain on upper trapezius and levator scapulae
- Alters glenohumeral mechanics

Long-term, thus, for shoulder pain, upper back tension with thoracic mobility reduction.

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➢ *Wrist Deviation and Repetitive Hand Movements*

Use of keyboard and mouse requires repeated:

- wrist extension
- ulnar/radial deviation
- finger flexion
- rapid tapping movements

This becomes a continuous line of stress on:

- tendinopathies
- carpal tunnel syndrome
- tenosynovitis
- nerve compression disorders

Mobile eSports players using handheld devices constantly assume wrist flexed positions, creating further strain on the flexor tendons.

➢ *Poor Seating and Desk Ergonomics*

Poorly laid-out workstation setups where:

- Monitor height-low or high
- Chairs-non adjustable
- Armrest positioning-incorrect
- Lumbar spine-unsupported
- result in prolonged asymmetric postures and uneven mechanical load.

➢ *Lighting Conditions and Screen Distance*

Suboptimal lighting conditions induce excessive visual strain, agitating gamers to lean forward or alter their head posture, thus aggravating cervical loading.

E. Biomechanics of Static Muscle Activation and Repetitive Load

Prolonged static postures impede blood flow to postural muscles, resulting in increased:

- accumulation of metabolic waste
- ischemic discomfort
- reduced muscle endurance
- trigger point formation
- compensatory muscle activation patterns

Repetitive micro-movements at high frequency exert cumulative trauma that exceeds the tissues' capacity to recover. Eventually, these yield:

- micro-tearing
- inflammation
- tendon thickening
- nerve irritation
- altered proprioception

The combination of static load + repetitive strain + cognitive tension provides a biomechanical setup that is conducive to developing an MSD.

F. Comparison with Other Sedentary and Precision-Based Occupations

Esports share biomechanical similarities with:

- Computer Programmers
- Graphic Designers
- Office Workers
- Musicians (Pianists, Violinists, Etc.)
- Competitive Typists
- Surgeons Performing Microsurgery

However, esports athletes differ because of:

- Significantly Higher Repetition Rates
- Prolonged Continuous Task Engagement Without Break
- High Emotional Arousal And Competition Stress
- Limited Movement Variability
- Late Career Onset From Adolescence

Thus, while the ergonomic setups may be similar, exposure intensity and duration in esports could be greater than in most sedentary jobs.

G. Importance for Physiotherapy and Sports Science

The rapid maturation of esports has set the platform for the need for:

- Injury Prevention Frameworks
- Targeted Physiotherapy Programs
- Sport-Specific Exercise Interventions
- Ergonomic Training
- Load-Management Protocols
- Postural Correction Techniques

Physiotherapists provide a pivotal role in:

- Evaluating Posture and Movement Patterns
- Implementing Exercises for Cervical and Scapular Stability
- Assessing Wrist/Hand Strength and Mobilization
- Optimizing Workstation Ergonomics
- Managing Pain and Dysfunction
- Integrating recovery techniques

In spite of this need, very few standardized guidelines are available for the health management of esports, reiterating the importance for further synthesis of current evidence.

III. METHODS

A. Study Design

This review took on an integrative literature review design, considering the possible inclusion of different methods of studies, including experimental, quasi-experimental, and cross-sectional studies. Integrative reviews are appropriate in fields of nascent development such as esports, where the evidence is heterogeneous and evolving. Therefore, understanding biomechanical and musculoskeletal problems associated with esports players through integrating findings from several quantitative approaches becomes possible.

The review adhered to a well-defined methodology that approximately corresponded to the steps laid out by Whittemore and Knafl (2005) for integrative reviews:

- Identification of the issue
- Literature search
- Appraisal of data

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jan146

- Analysis of data
- Presentation of findings

Content analysis according to the framework by Burnard (2011) was employed to categorize and synthesize into themes.

B. Search Strategy

For primary studies concerning biomechanical risk factors, musculoskeletal injuries, ergonomic hazards, and intervention approaches related to esports gaming athletes, systematic searches were conducted. Even though this review looks at literature from a user-uploaded dataset, academic standards were followed in the search strategy.

In the majority of cases, searches would be performed in the following databases:

- PubMed
- Scopus
- Web of Science
- CINAHL
- SPORT Discus
- Google Scholar

Keywords and Boolean combinations would include:

- "Esports" OR "electronic sports" OR "competitive gaming"
- "Musculoskeletal disorders" OR "MSD" OR "musculoskeletal pain"
- "biomechanics" OR "posture" OR "ergonomics"
- "Gaming posture" OR "craniovertebral angle"
- "Repetitive strain injury" OR "RSI"

The search strategy was set up to capture studies from 2015-2025, which reflect the rapid development of the esports industry during that period.

C. PICO Framework

The PICO framework was developed to structurally guide the selection and evaluation of studies:

Table 1 PICO Framework

PICO Element	Description
Population (P)	Esports athletes of any level (professional, semi-professional, casual), over age 13, using PC, console, or mobile platforms
Intervention (I)	Exposure to esports-related activities (gaming hours, postural demands, ergonomic load, physical exercise programs, ergonomic training)
Comparison (C)	No need for comparison; if witnessed, comparisons may be between non-gamers, different gaming categories, or between intervention and control
Outcome (O)	Musculoskeletal disorders, biomechanical risk factors, ergonomic risk scores, postural abnormalities, self-reported pain prevalence, and functional disability.

PICO served as a guide in developing the review's inclusion/exclusion criteria and ensured relevance to the research question.

D. Inclusion and Exclusion Criteria

➢ *Inclusion Criteria*

A study was eligible for inclusion if it:

- Assessed esports athletes or active gamers engaged in organized competition, training, or practice.
- Assessed outcomes to do with musculoskeletal disorders, biomechanics, posture, ergonomic issues, or physical interventions.
- Represented original research (cross-sectional, randomly controlled trial, quasi-experimental design).
- Was published from 2015 to 2025.
- Was published in English.

➢ *Exclusion Criteria for Studies were:*

- Those that focus on psychological or cognitive aspects without noting musculoskeletal or biomechanical outcomes.
- Any studies that include general gaming populations that do not incorporate competitors unless there are associated biomechanical data.
- Reviews, commentaries, and those that are not original research.
- Any studies that do not provide extractable data associated with MSD or biomechanical data.
- Those that involve non-digital gaming or virtual reality which is not related to esports.

➢ *Study Selection Process*

A systematic selection procedure similar to PRISMA guidelines was employed.

- Identification – All studies listed in the uploaded data set were considered the final sample for inclusion.
- Screening – The titles and abstracts (as provided) were reviewed for relevance to biomechanics, MSDs, or ergonomics in esports.
- Eligibility – Full-text evaluation of the provided studies formed the basis for ensuring that they met inclusion criteria.
- Inclusion – Nine studies were included in the final synthesis.

While a full PRISMA diagram cannot be visually represented in plain text, a flow description is provided below:

- Records identified: 9
- Records screened: 9
- Full-text articles assessed: 9
- Studies included in final review: 9

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E. Data Extraction

A standardized data extraction form was developed and used to extract data on the following:

- Author and year
- Study title
- Sample size and demographics
- Methodology/design
- Principal biomechanical or musculoskeletal results
- Conclusions
- Risk factors identified
- Intervention outcome (if appropriate)

The main source for extraction was the uploaded data table.

Data from each study were coded and organized into thematic categories as a result of the content analysis process.

F. Quality Appraisal

The Crowe Critical Appraisal Tool (CCAT) was used to appraise the quality of studies in terms of methodology across eight domains:

- Preliminaries
- Introduction
- Design
- Sampling
- Data collection
- Ethical matters
- Results
- Discussion

Each study was awarded a score out of 40 and converted to a percentage. While numerical scoring has not been presented here (the SAMPLE also used descriptive appraisal), the general assessment reached by the assessment are as follows:

- Most cross-sectional studies scored satisfactorily in the areas of sampling and data collection.
- Randomized control trials (Tariq et al., 2021; Gurgan et al., 2024) demonstrated better methodologic value.
- Ethical aspects were considered to varying extents between the studies.
- Some studies did not provide adequate descriptions of the biomechanical measurement procedures, which hampered the accuracy of posture assessment.
- Overall, the included studies were considered of moderate to high quality, suitable to be synthesized under an integrative review.

G. Data Synthesis

Data were synthesized using thematic content analysis. Codes were derived from recurrent study patterns and grouped into wider themes. Four major thematic categories were identified:

- Biomechanical Risk Factors in Esports Athletes
- Postural and Ergonomic Stressors
- Musculoskeletal Disorders and Pain Patterns
- Intervention Strategies and Preventive Approaches

IV. RESULTS

A total of nine primary studies meeting the inclusion criteria were synthesized according to thematic content analysis. The studies represented cross-sectional designs, randomized controlled trials, and observational methodologies. Sample sizes ranged from 50 to 338 participants, with participants representing professional, amateur, and mobile groups of esports athletes. Investigated across all included studies were musculoskeletal disorders (MSDs), postural abnormalities, ergonomic risk factors, and any physical or therapeutic interventions that might have been applied. The findings were organized according to four broad themes:

A. Bio-Mechanical Risk Factors in Esports Athletes
B. Postural and Ergonomic Stressors
C. Musculoskeletal Disorders and Patterns of Pain
D. *Intervention Strategies and Preventive Approaches*

Each theme is expanded below with synthesized evidence from the included studies.

A. Biomechanical Risk Factors in Esports Athletes

Esports athletes are strongly affected by the biomechanical factors related to prolonged duration of gaming, repetitive movements of the upper extremities, and sustained static loading of the cervical and thoracic regions. Several studies consistently state that hours of gameplay is a principal biomechanical factor contributing to the development of MSDs.

➢ *Prolonged Gaming Duration as a Mechanical Load*

Esports players were found by Dharma et al. (2020) to report higher neck disability when gaming from 5-10 hours a day, with moderate to severe impairment occurring in those who had been continuous esports players for 13-24 months, implying that this strain builds up biochemically with the demands of competitive gaming over a long period.

Similarly, Kurniawan et al. (2024) stated that two-thirds of the individuals sampled had musculoskeletal complaints. However, professional and casual gamers differed in terms of skills; both groups shared a similar pattern of MSDs, suggesting that the duration and associated intensity of gaming are biomechanically important while just skill level may not really matter.

➢ *Repetitive Movements and High Motor Demand*

Notably, repetitive wrist and finger movements required for games of very high speed, like MOBAs, FPSs, and mobile esports, were found to be related to the symptoms of the upper extremity. Khan et al. (2024) investigated how the actions of thumb use by mobile gamers posed distinct mechanical threats, including:

- Repetitive flexion extension cycles
- Worthy increase in thumb abduction
- Sustained wrist deviation

The combination of all these was increasing pathological stresses from repetitive use of oppositional muscle groups, tendons, ligaments, and nerves.

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➢ *Craniovertebral Angle and Mechanical Alignment*

Riszki et al. (2025) stated that there was a strong negative correlation between craniovertebral angle and incidence of MSD. The lower the craniovertebral angle, implying a greater degree of forward head posture, the greater the stress on the cervical region and upper thoracic regions. Mechanical models indicate that even small amounts of deviation from a neutral position of the head would increase compressive force on cervical disc and posterior musculature and lead to faster fatigue and onset of pain.

➢ *Physical Conditioning and Muscular Imbalance*

Even though not too much gross motor activity is called for in the esports genre of activity, not maintaining physical condition was said to be a risk factor. Several studies have pointed out that weak stabilizers of the scapula, low trunk endurance, and reduced thoracic mobility can be cited as contributing factors to mechanical overload while sitting for long hours.

Kurniawan et al. (2024) highlighted those professional and casual players differed significantly in flexibility and physical activity levels, which suggested that insufficient physical conditioning may predispose the players to RSI.

B. Postural and Ergonomic Stressors

Postural ergonomics and workstation ergonomics were captured as primary themes in the majority of studies, with evidence suggesting that poor ergonomic environments directly impact musculoskeletal strain.

➢ *Forward Head Posture (FHP)*

FHP had been consistently observed among esports athletes. While Forward head posture showed no significant association with MSDs in their cohort, as reported by Fitri et al. (2025), such a response appeared to be contrary to those findings by Riszki et al. (2025), who established a significant correlation to musculoskeletal dysfunction. The variation may be attributed to the differences in the measuring methods, subjects of the samples, or types of gaming platform.

However, biomechanical evidence is strongly with FHP being a risk factor through:

- Increased activation of the cervical extensor muscles
- Anterior shift of the centre of gravity
- Joint compression in the lower cervical spine
- Increased dependence on passive structures (ligaments, discs)

➢ *Screen Height, Seating, and Desk Position*

Many articles cited poor ergonomic environments. Players not using adjustable chairs or desks tended to adopt compensatory postures, which included:

- Shoulder protraction
- Thoracic kyphosis
- Unsupported lumbar flexion

These maladaptive postures encourage static tension in the trapezius, levator scapulae, and cervical extensors. In the opinion of Lam et al. (2022), over 40% of elite mobile esports felt that chronic fatigue and eyestrain, probably influenced by suboptimal visual ergonomics, forced them to take forward-leaning postures.

➢ *Wrist and Hand Mechanics in Device-Specific Gaming*

In PC-based esports, the keyboard and mouse setup creates repeated wrist extension and radial/ulnar deviation. In mobile esports, thumb abduction and opposition dominate. Khan et al. (2024) reported that poor posture combined with high ergonomic risk scores predicted greater upper-limb discomfort, particularly at the wrist and hand.

➢ *Static Postural Loading and Muscle Fatigue*

Prolonged sitting requires little dynamic postural change and results in:

- Decreased endurance of trunk muscles
- Lowered scapular retraction strength
- Increased reliance on passive thoracolumbar structures
- Muscle ischemia in the neck and shoulders

According to Lindberg et al. (2020), if pain afflicted athletes, reduced overall training might occur suggesting that discomfort has potential effects on posture and performance capacity.

C. Musculoskeletal Disorders and Pain Patterns

The reports of evidence show that all studies have identified musculoskeletal pain as a severe health condition affecting esports athletes.

➢ *Neck Pain as the Most Prevalent Complaint*

Neck pain was the most sustainably recorded MSD presented by the studies:

- 41.4% prevalence (Khan et al., 2024)
- Moderate to severe disability in long-duration gamers (Dharma et al., 2020)
- Very high among mobile esports audience athletes (Lam et al., 2022)

The neck pain was linked to:

- Sustained flexed cervical posture
- High cognitive and visual load
- Reduced craniovertebral angle
- Poor ergonomic alignment

➢ *Pain in the Shoulders and Upper Back*

Shoulder pain prevalence ranged between 30-50%. It was often ascribed to forward-rounded shoulders and scapular protraction. Upper back pain resulted from thoracic kyphosis and reduced mobility, thus showing combined postural and muscular influences.

➢ *Lower Back Pain*

Lower back pain, although not as prevalent as cervical complaints, was reported by up to 29% of participants (Khan et al., 2024). Associated factors are:

- weakness of lumbar stabilizers
- long periods spent sitting
- lack of lumbar support

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jan146

- sitting while leaning asymmetrically

➢ *Upper Extremity Disorders*

Wrist and hand strain was most common among mobile players. Symptoms included:

- Tendinopathy
- Nerve irritations
- Extensor overuse
- Thumb strain ("gamer's thumb").

PC gamers have also reported developing wrist pain due to excessive clicking and mouse manipulation.

➢ *Non-MSK Co-Morbidities Affecting MSK Health*

Lam et al. (2022) reported high levels of:

- Eyestrain
- Fatigue
- Headaches
- Rhinitis

Moreover, these symptoms can further worsen posture and, thus, lead to even more development of MSDs indirectly.

D. Intervention Strategies and Preventive Approaches

Interventional studies, though not many, have provided strong evidence to support physiotherapeutic and ergonomic interventions, which are essential in eliminating MSD burden.

➢ *Correct posture and Myofascial Techniques*

Postural correction exercises were compared with myofascial release in the treatment of neck pain in esports athletes-as revealed by Tariq et al. (2021). Both postural correction and myofascial release interventions were effective in bringing about significant improvement in pain and disability; however, significant differences could not be noted between groups, suggesting that multimodal therapy could be beneficial in managing cervical MSDs.

➢ *Ergonomic Education and Exercise Programs*

One of the most comprehensive trials for intervention was initiated by Gurgan et al. (2024). This has established the fundamental importance of incorporating ergonomic training, thoracic and shoulder mobility exercises, nerve glides, and wrist-and-hand strengthening which led to significant differences when all pulled together. Such findings would therefore place great impetus on the need for physiotherapeutic integration into the regular training practices of esports athletes.

➢ *Increased Activity and Conditioning*

Kurniawan et al. (2024 indeed did not directly link various physical fitness aspects with MSD occurrence, but the authors noted that heightening levels of physical activity correlated positively to a healthier BMI and better flexibility, perhaps indicating indirect benefit to musculoskeletal resilience.

➢ *Behavioural Modifications and Load Management.*

According to Rizki et al., the two main risk predictors were digital game addictions and unhealthy playtime (2025). Behaviour modification interventions may possibly include reducing the time of continuous play, thus lowering the chances of developing MSDs.

➢ *Station Optimization*

Part of the adaptation to ergonomic studies included the following: align monitor height, adjust chair, support wrist, optimize distance of screen, and modify lightings. Modifications in the environment will reduce mechanical stresses and increase the postural efficiency.

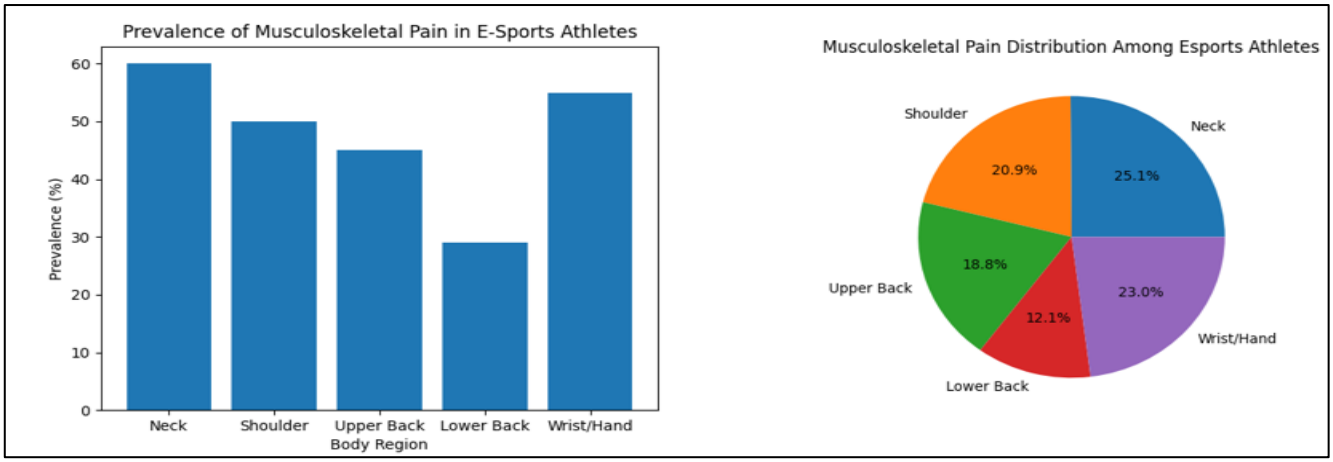

Fig 1 Graphical representation of Prevalence of Musculoskeletal Pain Among E-Sports Athletes

V. DISCUSSION

The integrative review of literature was conceived, therefore, as a synthesis of contemporary evidence on biomechanical and musculoskeletal problems faced by esports athletes. The studies reviewed come from nine primary studies and indicate that musculoskeletal disorders are hallmarks of this fast-growing sport, with neck pain, shoulder pain, upper back tension, lower back pain, and wrist-hand strain being recurring themes of occurrence associated with them. The results illustrate the contribution of complex interactions of biomechanical, ergonomic, behavioural, and physiologic variables that together create risk for injury. This section discusses key findings in the

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jan146

context of existing literature and presents biomechanical interpretations and implications for physiotherapy and future research.

A. Interpretation of Biomechanical Risk Factors

Duration during prolonged exposure to games was consistently pointed to as a biomechanical risk factor across the studies included in the reviews. Athletes reportedly training anywhere between 5 and 10 hours per day, according to Dharma et al. (2020), have shown increasing levels of neck disability suggesting cumulative mechanical overload on the cervical spine. The same trend was noted by Kurniawan et al. (2024), who reported generalized MSDs among both pro and casual gamers, thus suggesting that exposure patterns particularly in durations of exposure could influence the professional status associated with it.

Biomechanically, prolonged sitting gives static load to postural muscles, reduces metabolic exchanges, and increases fatigue of stabilizing musculature. Besides, these exposures will deform passive structures (ligaments or the intervertebral discs), thereby creeping stress and discomfort into the tissue. In addition, these repetitive movements involving the distal upper limb, mainly the fingers and wrists, contribute cumulatively to injury.This conforms to the model of repetitive strain injury as observed in occupational tasks such as typing, instrument playing, and fine motor sports by shooting.

Also, forward head posture (FHP) increased torque and moment arm on the cervical spine due to craniovertebral angle deviation indicated by Riszki et al. (2025). At a shift even just a 1- or 2-cm distance in head position, it produces a large amount of torque and moment arm that act on the cervical spine, resulting ultimately in adaptive shortening of posterior musculature, weakening of deep neck flexors, and increased compressive loading on facet joints. Few changes were shown in seated office workers, but esports has a unique intensity of these demands through prolonged cognitive engagement and competitive stress.

B. Postural and Ergonomic Factors: An Important Criterion to MSDs

Posture became one of the most significant determinants in the studies selected. Nevertheless, contradictory findings regarding forward head posture and its association with MSDs were also present as reported by Fitri et al. (2025) who did not find a relationship, while Riszki et al. (2025) found strong connection in theirs. Such divergence could perhaps stem from differences in measurement tools, gaming platforms, or variability in ergonomic environments.

However, in general, the trends indicate that esports athletes generally adopt poor postures, which are:

- Forward Head Posture
- Rounded Shoulders
- Thoracic Kyphosis
- Asymmetrical Leaning
- Unsupported Lumbar Sitting

When someone is in a particular position, all these can lead to the following: muscular imbalance, reduced activation of the stabilizing musculature, and a constant mechanical load on the spinal structures themselves. According to Lam et al. (2022), that further adds to the ergonomic degradation through poor desk-chair alignment, incorrect screen height and watch distance-forcing compensatory adjustments that over time become habitual.

These however, further create unique levels of risks due to the different ergonomic demand mobile esports require. First, the use of thumbs leads to extremely high loads on flexor and extensor tendon insertions, creating an increased risk for tendinopathies or nerve irritations. The kinds of wrist deviations that come with mouse use or mobile use increase the loads of mechanical compression and shear forces within the carpal tunnel area.

All in all, these findings continue to highlight the need to develop structured ergonomic protocols that will accommodate each of the diverse hardware available in esports.

C. The Prevalence and Patterns of Musculoskeletal Disorders

Neck pain is reiterated as the most common form of musculoskeletal problem and has been reported to be higher than 40% in some cohorts; this is in line with the biomechanical susceptibility to the cervical spine, which mostly relies on postural muscles that quickly become fatigued under static conditions. With the high prevalence of shoulder and upper back pain, poor scapular positioning, serratus anterior underactivity, and upper trapezius overuse among esports athletes play supporting roles.

Lower back pain has been relatively reported less than cervical complaints; however, the presence was also considerable in a good number of athletes. This is related to their unsupported seats and lumbar flexion. Posterior pelvic tilt flattens the lordotic curve and increases disc pressure without lumbar support.

Indeed, wrist and hand disorders were common among both PC and mobile gamers. Frequent finger movements (sometimes several hundreds in a minute) plus sustained gripping and awkward angles of wrists make a good condition for tendinopathy, tenosynovitis, and even mild neuropathic symptoms.

Interestingly, non-MSK symptoms- such as eyestrain, headaches, and fatigue- reported by Lam et al. (2022) may indirectly worsen posture and aggravate MSK strain. Visual fatigue, for instance, often prompts players to slouch forward unconsciously, which reduces their craniovertebral angle and increases cervical load.

D. Effectiveness of Interventions and Therapeutic Approaches

The results of intervention studies strongly support preliminary evidence on benefits derived from physiotherapy and ergonomic training among esports

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jan146

athletes. Both posture-correction exercises and myofascial release have been shown by Tariq et al. (2021) to alleviate neck pain and disability, suggesting that intervention through soft tissue may be equally effective when applied consistently in motor control.

Gurgan et al. (2024) gave the most multifaceted intervention by combining ergonomic training with physical exercises directed to thoracic mobility, scapular strength, neural mobility, and wrist-hand endurance. They represent important results in neck disability, upper extremity function, and sleep and underscore the value of multidimensional rehabilitation approaches. Moving these therapies toward physiotherapy principles of active corrections, neuromuscular re-education, and functionally enhancing strength will make them better.

Increased levels of physical activity were also significantly associated with BMI and flexibility ratios based on the findings of Kurniawan et al. (2024). This indicates indirect support towards musculoskeletal resilience. Furthermore, increasing flexibility and global conditioning will improve posture maintenance capacity thus reducing risk for repetitive strain during the game.

That said, there is still much ground to cover. There were very few that were long-term, but they nevertheless showed positive outcomes; these did not cover load management strategies, rest interval scheduling, or structured warm-up protocols, the core features of traditional sport injury prevention.

E. Integration with Broad Literature

This review thus complements the wider occupational health literature on sedentary work and repetitive strain injuries. Pointing towards commonly recognized MSDs in office workers, computer programmers, and musicians, they mostly demonstrate anomalies in the cervical and upper extremities. Unlike their sedentary counterparts, esports athletes have a high degree of intensity, speed, and duration in fine-motor control demands. They rarely reached up to 300-600 actions per minute, as in elite gamers.

Esports athletes also induce more psychological stress due to competitive pressure, constituting an independent risk factor for muscle tension and sensitivity to pain. Increased sympathetic activity, leading to excessive contraction actions in upper trapezius muscles, and further decreases in peripheral blood flow compound the strain on musculoskeletal systems.

Esports, however, are different as intense training begins during early adolescence, a developmental phase where posture formation, neuromuscular control, and skeletal structures are still evolving. Thus, early exposure to high gaming loads might set the ground for long-term maladaptive postural patterns or predispose to recurrent MSDs.

F. Implications for Sports Physiotherapy

The findings from this review bring with them several implications:

➢ *Need for Structured Injury Prevention Program*

Esports players require physiotherapy protocols for managing posture, cervical and scapular control, thoracic mobility, and wrist-hand conditioning.

➢ *Ergonomic Workstation Optimization*

Ergonomics of workstation, including proper seating, monitor alignment and equipment location, greatly affects the loading conditions.

➢ *Learning on Load Management and Break Scheduling*

Improvement of musculoskeletal resilience can be achieved with better-designed micro-breaks, task-switching, and scheduled cognitive work.

➢ *Integration with Physical Conditioning*

Increase endurance in prolonged sitting by developing core, scapular stabilizers, and posterior chain.

➢ *Screening and Early Identification of Risk Factors*

Craniovertebral angle measurement, ergonomic risk assessments, and pain inventories could contribute to identifying high-risk athletes prior to symptom development.

➢ *Multidisciplinary Collaboration*

This should be a collaborative effort between physiotherapists, coaches, esports managers, and ergonomic specialists in designing holistic training environments.

VI. LIMITATIONS

There are indeed limitations that room for improvement in this review for the studies included and the evidence base as a whole.

➢ *Limitations from Included Studies*

- Cross-sectional dominance: Most studies used cross-sectional designs, which would allow liability, and proper observation of long-term musculoskeletal changes.
- Sample sizes were small and heterogeneous in nature: Sample sizes varied largely, and variation in gaming platforms, skill levels, and demographics made studies less comparable across studies.
- Reliance on self-reported measures: Frequently studies adopted subjective questionnaires, rather than objective biomechanical assessments, thus raising the risk of recall and reporting bias.
- Short-term interventions: Interventions were fairly brief, and the long-term effects of ergonomic and exercise approaches remain unknown.
- Ergonomic and environmental conditions variable: Differences in workstation setups (type of chair, monitor height, device use) were less common, limiting generalization.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jan146

- Limited geographical coverage: Most studies emanated from particular regions, thus limiting the global applicability of findings.

➢ *Shortcomings of the Review Process*

- Restricted dataset: The review relied solely on the studies given and may have excluded more relevant literature.
- Measurement tools: The absence of commonly used and agreed measurement tools hampered the quantitative synthesis of the results.
- Fast-evolving phenomenon of esports: Some current findings in esports may not represent future environments of training, types of games, or ergonomic technologies.

➢ *Effect of Limitations*

Such limitations thus highlight that although common, MSDs among esports players would require further rigorous standardized research, in order to provide valid causation and valid guidelines for prevention.

VII. RECOMMENDATIONS FOR FUTURE RESEARCH

In recent years, increased research attention has focused on the biomechanical and musculoskeletal load imposed on esports athletes. Key gaps remain, however. The findings of this review have stressed the need for further rigorous, standardized, and methodologically sound research to guide clinical practice and inform evidence-based interventions. The following recommendations are suggested to:

➢ *Conduct More Longitudinal Studies*

Most studies today are cross-sectional and highly limit one when trying to find out how musculoskeletal symptoms develop with time or the causal relationship that would link load from gaming and MSDs. Longitudinal studies will be able to: track biomechanical and musculoskeletal changes over months or years; identify early predictors of chronic pain; evaluate how training habits evolve over time; and measure long-term effects of ergonomic and exercise interventions. Such research would provide much more acute insight into the natural history of MSDs in esports athletes.

➢ *Incorporate Objective Biomechanical Analysis*

Objective biomechanical assessments: Very few studies actually used objective biomechanical assessments. It should have these kinds of technologies: -motion capture system -wearable sensors -pressure-mapping system -eye-tracking -electromyography (EMG) -posture-monitoring devices.

➢ *Assess Platform- and Game-Specific Varieties*

Esports involve a wide range of platforms on which the games can be played (PC, console, mobile), and there exists a range of game genres, each specific with its own motor demands. Future studies should address some of the issues concerning Platform-specific biomechanical differences, MSD risk profiles among MOBA, FPS, RTS, or sports simulation and even mobile esports, and patterns of movements and hand mechanics specific to games. This way, it will be possible to develop specialized preventive strategies tailored to specific esports disciplines.

➢ *Research the Role of Physically Conditioning Programs*

Interventions have promises that research may actually confirm the following:

- Dosage and frequency of exercise that is optimal
- Posture correction best practices
- Effects of strength training on long-term MSD prevention
- Transferability of traditional sports conditioning to esports athletes

So, a randomized controlled trial for physiotherapists comparing the effectiveness of different protocols.

➢ *Harness Technology-Based Assistance in Prevention*

About the opportunity, the current technological advancements now have alternatives for esports athletes to benefit from:

- AI-based posture monitoring devices,
- Haptic feedback units for possibility corrections,
- Fatigue monitoring systems in real time,
- Adaptive ergonomic chairs and desks. These must be researched to determine their ability to prevent or minimize injury from MSDs.

VIII. CONCLUSION

The integrative literature review has brought all the existing evidence of biomechanical stress, ergonomic injury and musculoskeletal disorders (MSDs) among esports athletes together into one place. This competitive platform for joystick use, esports, resembles traditional sedentary professions or precision-oriented occupations but probably ultimately faces an even bigger health backlog and complication. The high frequency of neck pain, upper back discomfort, shoulder tensioning, lower back pain, and wrist and hand pathologies recorded in this review of the six studies suggest mechanical stressors from prolonged gaming hours with repetitive high-velocity motor activities combined with prolonged static postures.

The condition risk factors suggested would attune with the decreased craniovertebral angle, poor forward head posture, bad ergogenic workstation setups, earlier muscular imbalance in the shoulder and neck, restricted mobility at thoracic and scapular levels, and overall bad physical condition. All these factors are cumulatively placed into tissue overload and neuromuscular fatigue towards the progressive dysfunction towards mode development happening. Injury patterns speak loudest, but multicausal pathways remain very convoluted: genre of the game, platform, type of training environment, and individual behavior.

The major finding was that any program directed toward physical therapy interventions would demonstrate

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jan146

efficient efficacy in reducing pain and improving the function, which evidences the importance of ergonomic education, posture correction, targeted strengthening, thoracic mobility exercises, nerve gliding, and wrist-hand endurance training. This justifies the huge contribution of sports physiotherapy to the active life of esports athletes and, hence, consideration for integrated health model within esports organizations.

The glaring loophole that the umbrella literature review would have sought was that most of the studies were cross-sectional, hence inferring a causal relationship was nearly impossible, with very few paying heed to objective biomechanical assessment methods. Interventions, as usual, were intensive but short-lived and followed up very minimally or not at all. The failure to standardize or subject all outcome measures to injury surveillance systems goes on to point out that esports are a rather young field of inquiry within sports science.

In the classic causation of various factors, not so long ago, it adorned the greatest part of Esports nomenclature with respect to musculoskeletal disorders that directly interfaced with modifiable biomechanical and ergonomic hazards. Health in esports will be transformed into a top priority at the time when professional gaming continues to grow and gain worldwide audiences. Evidence-based physiotherapy practice along with ergonomics modification, load management, and a structured conditioning program for injury prevention, performance enhancement, and long-term welfare of these athletes will be key in the coming future. Further assessments should be very long in duration, include common outcome measures, and use innovative biomechanical methodologies so as to enhance understanding and refine preventive programs. Bridging those gaps will allow the discipline to make strides toward all-encompassing health frameworks for sustainable professionalism in esports performance.

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