Musculoskeletal Pain in Students Under COVID-19 Conditions – A Translational Meta-Synthesis for Personalised Rehabilitation

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Abstract: *Background and objective:* During the era of COVID-19 narrative data have given evidence of musculoskeletal discomfort and pain in students and causal connections with modes of distance learning as well as psychosocial stress and despair are likely. This phenomenon appears underrepresented in medical research and efficient support is needed. The present article elucidates complex pathogenic factors and suggests self-regulation techniques for curative and rehabilitative purposes.

Methods: On the basis of empirical, psychophysiological and narrative data the present translational systemic meta-synthesis constructs a theoretical framework to elucidate musculoskeletal discomfort and pain in students under COVID-19 distance learning conditions.

Results: Remote learning in higher education entails two interconnected risk conditions. Excessive use of non-ergonomic notebook-based participation in classes goes hand in hand with 'poor' posture, neck tension and tight shoulders, muscle stiffness caused by immobility and eye strain headache. In addition to the adverse influence of excessive sedentary academic work on the students' mood and emotional wellbeing, a complex cluster of negative psychosocial conditions affects the musculoskeletal system: COVID-19 related anxieties, mental stress, anger and feelings of helplessness as well as social isolation and loneliness. Taking these pathogenic factors and previous studies on sports-based self-regulation techniques to modulate musculoskeletal pain into account, a curative and rehabilitative model for affected and/or at-risk students is suggested.

Discussion: Mono-causal and inflexible study designs of evidence based medicine seem to be unable to adequately represent the complex COVID-19 phenomenon and advanced techniques of dynamic systemic simulation gain momentum. This requires a new awareness of epistemology in medical and public health areas alongside enhanced translational research. From a practical perspective universities should enhance heath promoting and rehabilitative support which is tailored to control prevalent pathogenic conditions in students. This also brings challenges of post-COVID-19 issues and future pandemics into play. Controversial political and medical views as well as conflicting arguments about the suitability of measures and multifarious 'collateral damage' call for ideology-free and science-based collaboration.

Keywords: Action research, Back pain, Body awareness, Display screen equipment DSE, Medical epistemology, Musculoskeletal discomfort, Pandemics, Self-regulation, Tension-type headache, Visual display unit VDU.

INTRODUCTION AND PURPOSE

Claire, age 21, wants to become a teacher and studies mathematics and music. She is a healthy and socially engaged young lady with a slight tendency to myofascial pain syndrome including spasm in the masticatory muscles and tension-type headache.

Several months ago her department of mathematics switched to distance learning and Claire finds these online-classes stressful: It is hard to stay focused when gazing at the small screen of her laptop and possibilities to pose questions are limited. She also has the impression that under such conditions a constantly high level of mental concentration tends to increase muscle tension in the neck. Moreover, her shoulders feel tight and stiff and often she realises that during online classes her torso is twisted. For some weeks back pain has been developing, headache occurs more often and she has troubles to relax her jaw muscles.

Claire is not alone with her problems and especially under COVID-19 conditions many students experience similar difficulties. While from a preventive and rehabilitative orthopaedic perspective decisive action is needed, particularly demoralised students tend to trivialise risks and stick by the motto 'it's tough enough to survive somehow or other and there is neither energy nor time to worry about health'. This attitude, however, is dangerous and chronification of musculoskeletal conditions and associated pathologies are likely. Institutions of higher education are called to control these threats and corresponding research is needed. The present article explores relevant pathogenic conditions and suggests a curative and rehabilitative model, which is based on guided action research and self-regulation techniques.

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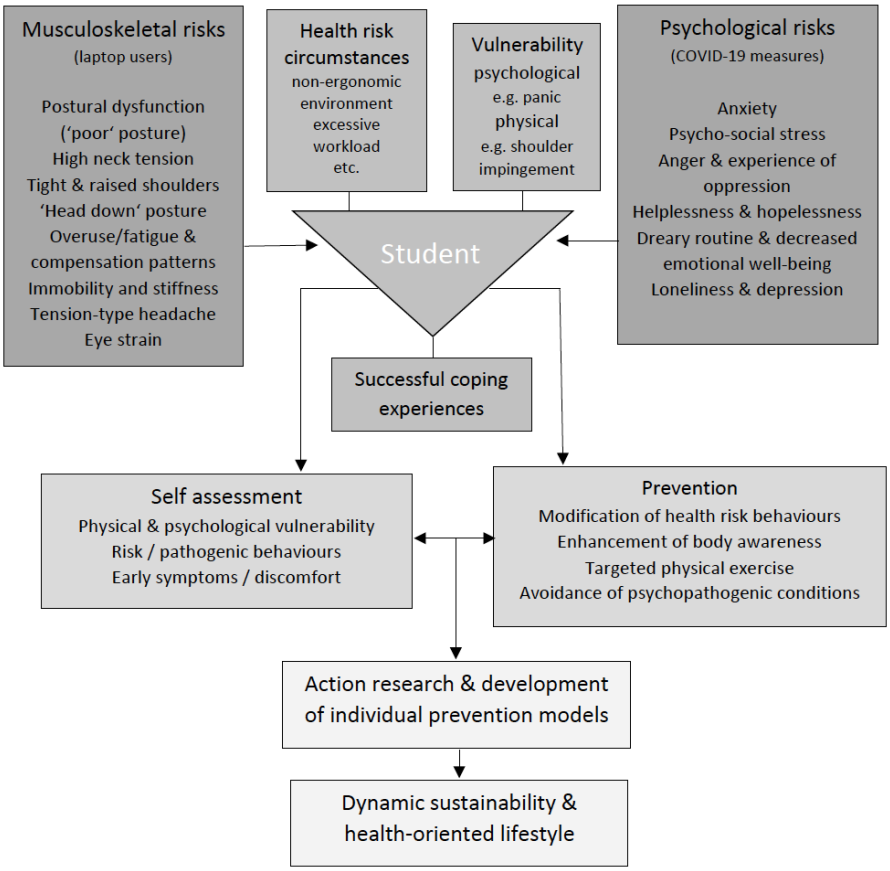

Graphical abstract: Musculoskeletal risks, discomfort and pain in students under COVID-19 conditions and remote learning circumstances.

RESEARCH METHOD: TRANSLATIONAL META-SYNTHESIS

At first glance the problem looks easy: COVID-19 policies decree distance learning, students spend much time with their notebooks, and because ergonomic computer work is healthier than laptop work [1] they are eventually facing health problems such as neck pain or tension-type headache.

From a medical perspective, however, things are not that easy and questions arise: How does laptop work-related bad posture impact on the development of musculoskeletal pain? How do psychosocial conditions such as mental stress contribute to postural dysfunction? How do COVID-19 measures influence the students' motor system and state of mind? How do complex individual vulnerability factors increase the risk of musculoskeletal conditions in laptop users? And how can we develop feasible and efficient preventive, curative and rehabilitative interventions and facilitate their implementation in higher education?

Related exploratory research involves orthopaedic and psychosomatic sciences, clinical and physiological findings, personalised and narrative medicine, treatment methodology as well as epidemiological and socio-political studies, hence the decision to conduct a translational systemic meta-synthesis.

The model of systemic meta-synthesis was inspired by the meta-bias that in medical domains accumulated robustness of single studies is in the ascendant, while generation of ingenious new theories is on the decline. Although the pool of single data is immense, researchers – particularly in evidence based medicine areas – tend to not take advantage of these data's synergistic epistemological potential. The inner logic which inheres the entirety of these findings remains unearthed, as well as the complex nature of related dynamic, *e.g*. bio-psycho-social, systems.

In response to this deficiency, systemic meta-synthesis was designed as a model and technique to process data and findings of dissimilar characteristics, *e.g*. (quantitative) effect sizes in RCTs and narrative data from personalised medicine, as well as to explore their substantial interconnections.

The present systemic meta-syntheses involves three different data areas: (i) basically quantitative

findings on behavioural and psychological impacts on musculoskeletal health, particularly with regard to laptop users, (ii) analyses of multidimensional sociocultural dynamics and changes as well as their impact on campus life, distance learning, students' home office, as well as physical and mental health (iii) narrative data from students under complete or partial distance learning conditions.

There are two main ways to mount a systemic meta-synthesis: a bottom-up and a top-down mode. In bottom-up mode studies on a given issue or thematic field are taken into consideration and explorative comparative processing aims to trace general principles as well as their inner logic and coherence. The top-down mode starts with a given hypothesis and goes on searching for confirmatory or contradictory evidence. The present study formulated the hypothesis that COVID-19 measures can cause musculoskeletal discomfort in students, hence the top-down mode.

Systemic meta-syntheses implicitly consider system compatibility between their components and so they generate 'powered hypotheses'. Moreover, meta-syntheses take – and this is considerably different from common practices in evidence based medicine – coherence sizes into account. From the perspective of philosophy of science both systemic meta-syntheses and, for instance, 1A level of evidence studies are comparable: Both are based on a scientifically plausible trust in the possibility of generalisation and related knowledge generation, and both suggest (relatively) reliable tendencies.

The term 'translational' concerns the study's main focus on students' risk factors for musculoskeletal conditions as well as preventative and rehabilitative means, and the whole is designed as a contribution to applied research: Starting from narrative data it constructs an exploratory scientific framework and concludes with a self-regulation model for students to control and modulate work-related musculoskeletal issues.

PATHOGENIC FACTORS OF STUDENTS' WORKING CONDITIONS

During the COVID-19 era German universities provide classes on the basis of distance learning. The British Education Endowment Foundation (EEF) [2] pointed out that the effectiveness of remote teaching is determined by many of the same factors as determine the effectiveness of live classroom teaching such as ensuring pupils receive clear explanations, supporting growth in confidence with new material through scaffolded practice, application of new knowledge or skills and enabling pupils to receive feedback on how to progress – and these guidelines also apply to higher education.

Nonetheless, these points only relate to the quality of teaching and not to the students' learning environment. In Germany, conservatoires and universities of music are allowed to provide live teaching if settings comply with strict hygiene regulations issued by the government. This is important as, for instance, ensemble improvisation cannot be performed in remote mode. Between these courses many students seek empty places and attend remote classes, sitting on a chair or stool, laptop on their knees, gazing at the screen, immobile like turned into stone, tight neck, uneven shoulders, curved spine and seemingly stressed. From an orthopaedic, neurological and psychosomatic perspective how they complain about issues such as neck pain, headache or trembling fingers does not surprise. And yet, these signs might be the starting point of chronic musculoskeletal and neuromotor disorders and thus call for focused attention and support.

Students – An Orthopaedic at-Risk Population

Work-related musculoskeletal conditions in university students are not new – and today they often go hand in hand with a phenomenon researchers from Brazil called the 'head down generation' [3]: frequent use of smartphones are associated with a tendency to musculoskeletal pain, mostly in the cervical region, and those who type on their phones with the head at 45° and 60° angles are about twice as likely to have higher scores of severe symptoms than those typing with their neck at 0°, which is the anatomical position. Consistent with these findings a Taiwanese study [4] examined specific components of smartphone use and their relationship to musculoskeletal discomfort and stepwise regression results indicated that the number of body parts with discomfort increased with hours spent using ancillary smartphone functions.

In general, the use of electronic devices such as smartphones and computers increases the risk of musculoskeletal discomfort in university students, particularly including upper limb symptoms such as neck and shoulder pain, and consequently researchers highlighted the urgent need for ergonomics education and recommendations to increase the students' awareness of musculoskeletal wellbeing [5].

As regards connections between posture related musculoskeletal discomfort and the use of computers among university students, a study from Pakistan [6] found a positive association of musculoskeletal discomfort with the duration of computer use, and significant differences were observed in musculoskeletal discomfort scores based on the type of posture adopted. However, 'no significant differences were observed in terms of discomfort based on gender, ergonomic awareness and type of computer used'.

These conclusions about ergonomic awareness stand in stark contrast to the results of the present study – differences in understanding the term 'ergonomic awareness' are likely and comprehensive body awareness including dynamic self-exploration of how musculoskeletal discomfort and ergonomic use of electronic devices are interconnected comes into play.

Notebooks, Screen Work and Musculoskeletal Issues

For some decades visual display units (VDU) have progressively become a commonplace equipment. Whether in office or factory or 'home office', individuals repeatedly reported musculoskeletal complaints and assumed causal connections with their work – and research was called to examine pathological conditions and risks. In the year 1995 two important studies were published and contributed to related discussions in occupational medicine and orthopaedics.

The study from Singapore [7] called visual display terminals (VDS) an occupational task with both 'benefits and hazards' and pointed out that the debate about the relationship between musculoskeletal disorders and VDT usage usually centers around occupational factors (*e.g,* constrained posture, poor ergonomic design of the workplace, equipment design), work-related psychological factors (*e.g,* perceived high job demands, mundane, boring and repetitive job activity, little control, poor support from colleagues and superiors), and psychosocial factors (*e.g,* biodemographic characteristics such as age, previous musculoskeletal injuries, emotional stress, family burden, environmental factors).

Until today these perspectives are useful to constitute adequate frameworks in this domain. The other study [8] – from Sweden – distinguished organisational (*e.g*. rest breaks, peer contacts, task flexibility and overtime) and ergonomic variables such as static work posture, hand position, use of lower arm support, repeated work movements and keyboard or VDT vertical position.

Consistent with these findings, Wahlström's review [9] about interdependencies between ergonomics, musculoskeletal disorders and computer work hypothesised that 'perceived muscular tension is an early sign of musculoskeletal disorder, which arises as a result of work organizational and psychosocial factors as well as from physical load and individual factors ... perceptions of exertion and [dis] comfort are other possible early signs of musculoskeletal disorders in computer work' – and these findings relate to core issues of the present article.

Notwithstanding, the question how and to what extent working with display screen equipment and musculoskeletal disorders are correlated remained a controversially discussed topic and a review from Norway [10] spoke of limited evidence for a causal relationship between computer work, wrist tendonitis, forearm disorders, tension neck syndrome and other musculoskeletal diagnoses of the neck and upper extremities, including shoulder tendonitis and epicondylitis. A recent Polish review [11], by contrast, pointed out that work performed in a sitting position, despite the fact that it does not require a lot of physical effort, can be the cause of many musculoskeletal disorders, especially when performed for a long time and in the wrong position and emphasised that musculoskeletal disorders are currently a common problem in the working population.

Today, a wealth of studies on orthopaedic issues associated with extensive laptop work substantiate such findings. Upper extremity musculoskeletal discomfort [12] is prevalent and students using laptops on their knees or low height tables are particularly at risk [13]:

> The number of laptop users experiencing musculoskeletal disorders (MSDs) has increased drastically due to, in part, inappropriate workstations ... [and] high neck flexion and pain were found while working at sofa and bed, whereas high muscle activity at shoulder and upper back pain were found while working at the low-height table.

The present article emphasises the vital importance of behavioural factors, while an American ergonomic training programme for student notebook users focused first and foremost on the role of external accessories for health benefits [14]:

> The use of an external keyboard resulted in a reduction in neck and shoulder pain. Participants self-reported fewer headaches when using an external mouse. Using no external accessories was associated with self-reported back pain. Although other musculoskeletal discomforts decreased over time, the changes were not statistically significant.

As regards the interconnection between poor posture, mental concentration and eye strain during student laptop work, as well as related issues such as eye strain headache, an ophthalmological study on computer vision syndrome (CVS) [15] emphasised that 'CVS may have a significant impact not only on visual comfort but also occupational productivity since between 64% and 90% of computer users experience visual symptoms which may include eyestrain, headaches, ocular discomfort, dry eye, diplopia and blurred vision either at near or when looking into the distance after prolonged computer use'. Multiple ophthalmological and orthopaedic symptoms in laptop users [16] are challenging and a recent study focused particularly on complex conditions in students [17]:

> The most common symptom due to prolonged computer use was neck or shoulder pain, reported by 82.2% of the subjects. Overall, 66.5% of the subjects suffered from headache and 51.5% from dry eyes, in mild, moderate, or severe form. Business students were 1.6 times as likely as medical students to suffer from computer vision syndrome ... The use of electronic devices for more than 5 h ... was also associated with experiencing computer vision syndrome symptoms.

Such findings call for targeted information campaigns and enhanced support of students alongside precise identification of vulnerability and risk-factors. Preventive measures require personalised medical interventions such as effective self-regulation techniques.

VICIOUS CIRCUITS AND PATHOLOGICAL SYSTEMS

Evidence based medicine basically generates quantitative mono-dimensional comparative data alongside quality criteria such as effect size and statistical power. Analysis of narrative material about students with musculoskeletal discomfort, however, indicates complex, dynamic and multi-modal pathological realities and pertinent scientific approaches are needed. The following sub-chapters shed light on interdependencies between COVID-19 circumstances, psychosocial conditions and musculoskeletal discomfort in students in higher education and suggest powered hypotheses for targeted therapeutic interventions.

Anxieties

Student self-assessment and self-exploration indicate marked correlation between anxiety and discomfort, musculoskeletal tension and pain included. Features of these anxieties may vary individually and consist of dynamically interconnected components such as (i) uncertainty about COVID-19 related conditions and regulations affecting their studies, as well as adequate academic support and final examinations, (ii) existential dread and confusion over future professional perspectives, (iii) experience of decreased self-reliance and freedom of choice together with (subliminal) fear of being punished for unintended or accidental violation of coronavirus regulations, (iv) fear of losing self-control and going insane, (v) fear of testing positive for COVID-19 and consequently being obliged to stay in quarantine and (vi) feelings of guilt about infecting or having infected others. This study's (informal) multicentre narrative data sample suggests relatively low fear of SARS-CoV-2 and/or COVID-19, though.

A huge amount of studies substantiate the prevalence of COVID-19 associated anxieties, sleep disturbances and suicidality [18], while qualitative studies exploring aetiological backgrounds and individual features of psychopathological phenomena are markedly underrepresented. In other words: there is detailed knowledge about severity levels and correlations but lack of insight into the subjective reality of mental load and emotional burden. Quantitative empirical studies yielded statistically (not necessarily epistemologically) robust data about anxiety, stress and depression in various regions during different COVID-19 phases, *e.g*. in the initial stage in northern Spain [19], and in different populations and samples such as pregnant women [20], as well as COVID-19 related behavioural changes in physical activities, sleep, tobacco and alcohol use [21] etc. From a broader perspective of medical epistemology, however, taking qualitative data into account is vital and it makes a huge difference whether people are afraid of SARS-CoV-2 or political action – in short, the viral infection itself or the how policies impact on social life and existential stability.

COVID-19 is associated with anxiety, students feel worried and have musculoskeletal issues. Whether and how their pervasive fear and physical discomfort are interrelated asks for the missing link. Animal models suggest an important impact of anxiety on musculoskeletal pain and discuss, for instance, the role of astrocyte activation [22], long-term adolescent multisite musculoskeletal pain is associated with psychological distress and anxiety [23], and a study from the Federal University of São Paulo summarises [24]:

> Musculoskeletal pain (MP) is common in the general population and has been associated with anxiety in several ways: (a) muscle tension is included as a part of the diagnostic criteria for generalized anxiety disorder, (b) pain can be a common symptom and a good indicator of an anxiety disorder, (c) anxiety is an independent predictor of quality of life in patients with chronic MP, (d) anxiety leads to higher levels of pain chronification, and (e) fear, anxiety, and avoidance are related to MP.

From a systemic point of view, the broad spectrum of findings provides pertinent insights into the complex dynamics of COVID-19 related anxieties, as well as underlying mechanisms of musculoskeletal pain and VDU work associated overuse syndromes. Quantitative studies, which assess the number of at-risk and affected students, pathological levels and symptom correlations, and qualitative studies, which mirror individual conditions, vulnerability and pathological realities, have to complement each other so as to facilitate appropriate preventive and rehabilitative means.

Mental and Psycho-Social Stress

There are a lot of contentious views about the COVID-19 state of emergency and critical voices have brought the legal concept of proportionality into play. Be that as it may, COVID-19 related conditions considerably impact on academic life and according to narrative data students are experiencing a broad spectrum of mental stressors such as unclear and frequently changing regulations, feelings of helplessness, lack of peer reassurance and eroded social cohesion, difficult adjustment to new learning conditions and conflicts between contradictory attitudes towards SARS-CoV-2 and COVID-19 policies. As regards scientific research, these distinct issues require mixed methods comprising qualitative and quantitative, narrative and statistical approaches.

Psychological stress in the general population during the COVID-19 pandemic is a common occurrence and a systematic review and meta-analysis [25] estimated a 29.6% prevalence. Consistent with these findings Canadian researchers [26] pointed out that emerging evidence suggests rates of posttraumatic stress and psychological stress in the general population are elevated due to COVID-19 and estimated the pooled prevalence of posttraumatic stress symptoms and psychological stress at about 24%. Moreover, the authors touched upon a frequent meta-theoretical issue: they noted that prevalence of stress symptoms was higher in unpublished compared to peer-reviewed studies. From the perspective of theory of science, this incongruence calls for critical epistemological clarification and does not necessarily indicate a higher reliability of the peer-reviewed papers.

Stress-related musculoskeletal pain counts among common medical conditions and a study from the Centre for Military and Veterans Health in Adelaide, Australia, [27] pointed out that 'while stress is often considered by patients and clinicians alike as an important factor in the onset and maintenance of widespread musculoskeletal pain, the relationship is more complex than appears on initial consideration. The types of event that lead to stress need description, and the role of traumatic events are particularly important because of the shared association with post-traumatic stress disorder' – and this standpoint widely coincides with main perspectives of the present article.

Substantiating the aetiological role of psychosocial stress for the development of chronic musculoskeletal pain disorders Valentina Buscemi and her team [28] aimed to inform clinicians about the importance of an early identification and treatment of individuals who present with acute musculoskeletal disorders accompanied by a high level of stress – and the present article refers analogously to universities and campus management.

With far-reaching consequences for the topic of musculoskeletal issues in students various studies particularly emphasised the close correlation between psychosocial stress and musculoskeletal pain in adolescence [29, 30] and advocated implicitly key demands of this paper: to enhance the awareness of musculoskeletal risks in students who are faced with multi-modal mental stress – and a study from Hong Kong [31] afresh highlighted the relationship between cumulative use of electronic devices, psychosocial stress and musculoskeletal symptoms.

Anger and Helplessness

Numerous broadly educated students are also familiar with medical viewpoints such as the Great Barrington Declaration [32], which was issued by high ranking infectious disease epidemiologists and public health scientists who expressed their grave concerns about the damaging physical and mental health impacts of the prevailing COVID-19 policies. Moreover, they recommended 'focused protection' and suggested that those who are not vulnerable should immediately be allowed to resume life as normal and in particular that schools and universities should be open for in-person teaching – and these are plausible reasons why students are angry at politicians and their coronavirus regulations which 'mutilate' academic life.

Narrative data suggest a certain tendency towards a correlation between COVID-19 policy related resentment and musculoskeletal discomfort: neck tension alongside involuntary body-expressions which remind of shaking off water or twist so as to resist a burden, by way of illustration. Psychology substantiates such potentially subliminal symbolisations and psychoanalytic explanations of conversion disorders [33] spring to mind. Taking into account that students may experience such restrictions as injustice a Canadian study [34] on the interconnection between anger, perceived injustice and chronic pain comes into play. Also consistent with other studies on this topic the authors pointed out that 'high scores on a measure of perceived injustice were associated with greater pain, more severe depressive symptoms, and more pronounced disability'.

Although students may feel angry that COVID-19 measures harm their study conditions, efforts to rein in one's temper and to repress the wrath cannot solve the problem and both psychosomatics and cognitive psychology cast light on the interrelation between anger inhibition and pain modulation. With focus on this connection, scientific findings [35] support the cognitive resource hypothesis that overuse of emotional inhibition in high anger-inhibiting individuals can contribute to cognitive resource deficits and thus increase pain risk.

Being confronted with COVID-19 regulations and their adverse impact on study conditions and campus life, forced 'home office' included, anger also tends to be associated with feelings of helplessness. This combination is likely to enhance pain perception and a German study [36] found that – compared to controllable stress conditions – uncontrollable stress exposure lead to significantly higher perceived pain intensity ratings and higher subjective helplessness. Broadly speaking, musculoskeletal conditions and psychosocial strain are complexly intertwined and COVID-19 associated symptoms and syndromes in students require multidimensional approaches, psychosomatic and psychological disciplines included.

Sedentary Work and Decreased Emotional Well-Being

Sophia, a student of intercultural studies, tested positive for COVID-19 and had to stay at tome in mandatory quarantine. In her little one-room flat, which is not located at the campus, she began to go stir-crazy and felt like being in prison. As usual, she used her step tracker watch and realised her daily average of 10000 sank to about 100. Except two days of mild cough she was symptom-free, yet the 'house arrest' had a huge impact on her mood, physical activity and energy.

Regarding the life-altering challenges due to the COVID-19 pandemic and the new normal social distancing and 'shelter in place', US-American researchers [37] spoke of an encounter of two pandemics: COVID-19 and sedentary behaviour; and referring to the World Health Organization they pointed out that '31% of individuals 15 years or older are physically inactive and approximately 3.2 million deaths per year are attributed to this unhealthy lifestyle behavior'.

COVID-19 policies which include curfew, quarantine, home-office and inhibition of sports are inextricably linked with a decline in physical activity and ANSES [38], the French Agency for Food, Environmental and Occupational Health & Safety, raised the questions 'whether, why, and how to deal with short- or medium-term lockdown-related physical inactivity and sedentary behavior increases'. Moreover, the authors drew attention to short-term and unknown long-term impacts on mental health and well-being, physical fitness and eating behaviors in children and adolescents:

> Overall, considering children and adolescents, the emerging risk justifies proposing specific adaptations and type of activities in order to ensure maintaining health underpinned, at least partly, by physiological equilibrium and physical fitness and avoid the installation of new unhealthy habits or routines that young people could keep after lockdown.

Implicitly qualifying such criticism of restrictive corona policies, an observational cross-sectional pre-post study from the University of Castilla-La Mancha [39] showed that lockdown-conditions do not necessarily cause a decline in physical activity and in some cases even increases could be observed. And yet, responsive behaviour of that kind depends on many factors including self-images, sports facilities at home and the interpretation of lockdown phases as 'gift of time', and socio-cultural views and traditional attitudes play a decisive role as well.

Notwithstanding these limitations, COVID-19 policies are likely to entail serious risks such as modified physical activity habits and their negative influence on the metabolic equilibrium [40], pathogenic sequelae of social isolation comprising increased physical inactivity alongside the aggravation of 'the global burden of cardiovascular disease' [41] and a broad spectrum of orthopaedic issues such as limited care opportunities for patients with musculoskeletal pain [42] alongside a marked reduction in musculoskeletal trauma patients undergoing surgery, as well as significant changes in types and mechanisms of injury: 'and, concerningly, mortality of trauma patients has risen significantly' [43].

Together with evidence based inferential reasoning, the present article emphatically advocates personalised medicine as well as recognition of individual pathogenic factors of musculoskeletal issues in students, and two circumstances are of decisive influence: (i) COVID-19 policies are likely to cause a sedentary lifestyle in the younger generation [44] and (ii) sedentary workers are at high risk of musculoskeletal disorders and need preventive and/or rehabilitative action such as exercise therapy [45, 46]. As regards students, this article suggests that these interventions be associated with guided self-administered orthopaedic rehabilitation programmes.

Loneliness

Using the milder term 'social distancing' COVID-19 policies yet cause social isolation. Researchers from India [47] pilloried that rational and logical conclusions have been replaced by 'biased and faulty decisions based on mere faith and belief' and expressed great concern:

> This social isolation leads to chronic loneliness and boredom, which if long enough can have detrimental effects on physical and mental well-being. The timelines of the growing pandemic being uncertain, the isolation is compounded by mass panic and anxiety. Crisis often affects the human mind in crucial ways, enhancing threat arousal and snowballing the anxiety ... the health systems are under severe pressure, mass hysteria has acquired a frantic pace and people's hope and aspirations are taking a merciless beating.

And calling loneliness a state of being without any company or in isolation from the community they spoke of 'a dark and miserable feeling, a risk factor for many mental disorders like depression, anxiety, adjustment disorder, chronic stress, insomnia or even late-life dementia'.

It is to be feared that certain politicians are not aware of the detrimental psychosocial impact of their policies and an Australian study [48] examined the social and psychological consequences of the COVID-19 pandemic 'with a focus on what this has revealed about the need to better understand and respond to social isolation and loneliness as public health priorities. Social isolation and loneliness are understood to be distinct conditions, yet each has been found to predict premature mortality, depression, cardiovascular disease and cognitive decline'.

From a psychological perspective we still have to differentiate between loneliness and social isolation and an international study [49] afresh sheds light on these phenomena during the COVID-19 era: 'While the term loneliness refers to subjective feelings, social isolation is defined by the level and frequency of one's social interactions. As a generally accepted concept, loneliness is defined as the subjective feeling of being alone, while social isolation describes an objective state of individuals' social environments and interactional patterns'.

Furthermore, the authors give an overview of the broad spectrum of physical and mental issues associated with loneliness such as elevated systolic blood pressure, increased risk for coronary artery disease-associated death, reduced sleep efficiency, increased depressive symptomatology, poor self-rated health, impaired functional status, vision deficits, and a perceived negative change in quality of life. Moreover, the COVID-19 phenomenon may increase suicide rates [50] 'during and after the pandemic. Mental health consequences of the COVID-19 crisis including suicidal behavior are likely to be present for a long time and peak later than the actual pandemic'. Broadly speaking, COVID-19-associated social isolation and loneliness have multiple negative impact on the mental health, children and adolescents included [51].

In orthopaedic circles and further areas concerned with musculoskeletal care, loneliness is mostly discussed in the context of diseases: self-perceived loneliness and rheumatoid arthritis [52], the beneficial changes in social isolation and loneliness after total hip arthroplasty and total knee arthroplasty [53] or the inner connection between loneliness and musculoskeletal pain in older adults [54]. In short: musculoskeletal pain increases the risk of loneliness [55], particularly in the older generation. In the present study, however, the other side of the coin comes into play: Can loneliness *cause* musculoskeletal pain?

A Stanford University School of Medicine study on the interrelationship between social isolation and pain interference [56] – this is the extent to which pain hinders an individual to participate in physical, mental, emotional, recreational and social activities – provided evidence that the impact of pain is reduced in individuals who perceive a greater sense of inclusion from and engagement with others: 'Cross-lagged longitudinal analysis showed that SI [social isolation] predicted PI [pain interference] at the next time point, above and beyond the effects of pain intensity and covariates, but not vice versa'.

Consistent with such finding, narrative data suggest that loneliness can both influence pain perception and cause painful musculoskeletal tensions. We observed two contrasting responses to loneliness. Both of them have potential to cause musculoskeletal pain and were accompanied by symbolic self-interpretation: (i) complete surrender and the impression of being crushed by the grief of isolation and (ii) the unsuccessful fight against the yoke of inescapable loneliness.

SELF-ADMINISTERED REHABILITATION

Due to their complex working conditions, which also encompass mental stress and musculoskeletal strain, now and again musicians serve as a model for clinical studies – and the Polish researcher Aleksandra Jacukowicz [57] conducted a systematic review which aimed to identify psychosocial job demands and musculoskeletal sequelae in musicians. Although the studies considered in her review suggested correlation between musculoskeletal pain and psychosocial factors such as long hours at work, work content, high job demands, low control/influence and lack of social support, Jacukowicz qualified that heterogeneous study designs did not allow consistent conclusions.

One year later Mastnak [58] published a sports medical study based on action research with more than 600 music students and suggested Karate-based self-regulation of musculoskeletal pain. Similarities with pathophysiological mechanisms of musculoskeletal issues in students under COVID-19 related remote learning conditions encouraged inductive conditional inference and narrative data were used to generate a preliminary conceptual framework.

Information

Today, several universities look wallpapered with information about surface disinfection, correct hand washing techniques, coronavirus face masks and social distancing: messages which are meant to reach the entire relevant population need appropriate distribution. Accordingly, information about physical and mental health in students under COVID-19 conditions should be distributed both on-campus and online and contain core information how to avoid medical conditions associated with extensive laptop-work, as well as how to get targeted support.

Self-Assessment

Referring to essentials of how to prevent and control discomfort, students are encouraged to particularly assess (i) their physical and psychological vulnerability, *e.g*. their susceptibility to tension-type headache or their propensity to panic reactions in social isolation, (ii) risk-behaviours such as pulling the spine out of alignment when seated and (iii) early symptoms of musculoskeletal disorders.

Self-Administered Preventative Measures

On the basis of pertinent information and concise self-assessment students are encouraged to adopt preventative measures comprising (i) modification of risk-behaviour, (ii) enhancement of body awareness and early detection of physical, psychological and combined symptoms such as spasmodic torticollis-like symbolic reactive 'convulsions' of the neck, by way of illustration, (iii) targeted physical exercise such as lumbar/core and neck strengthening, stretching, conscious control of postural dysfunction alongside body re-balancing as well as (iv) avoidance of psychopathogenic conditions, personalised coping strategies and equilibration of the self, *e.g*. by use of Tai Chi or Yoga models.

Curative and Rehabilitative Activities

In case of mild or moderate symptoms professionally guided development of personalised curative and rehabilitative models is suggested. The process starts with an initial intervention, which may be

derived from own promising experiences or are based on professional suggestions.

Action research traces back to Kurt Lewin's thought and consists of a spiral of dynamic feedback cycles comprising modifications of interventions, assessment of the re-designed interventions, analysis and interpretation of pre-post differences as well as related pros and contras – according to these findings re-construction of intervention techniques, and so on. Today action research is also recognised as a flexible means in personalised medicine and used in various health care domains, particularly for treating patients with chronic diseases and/or complex care needs [59, 60].

The present article suggests a modified version of self-administered action research (Figure **1**) in which students have a triple function: scientist, therapist and patient. Action research is both the 'therapeutic processor' and the heart of our model (Figure **2**), which is designed to control and alleviate musculoskeletal issues in students under COVID-19 associated remote learning conditions.

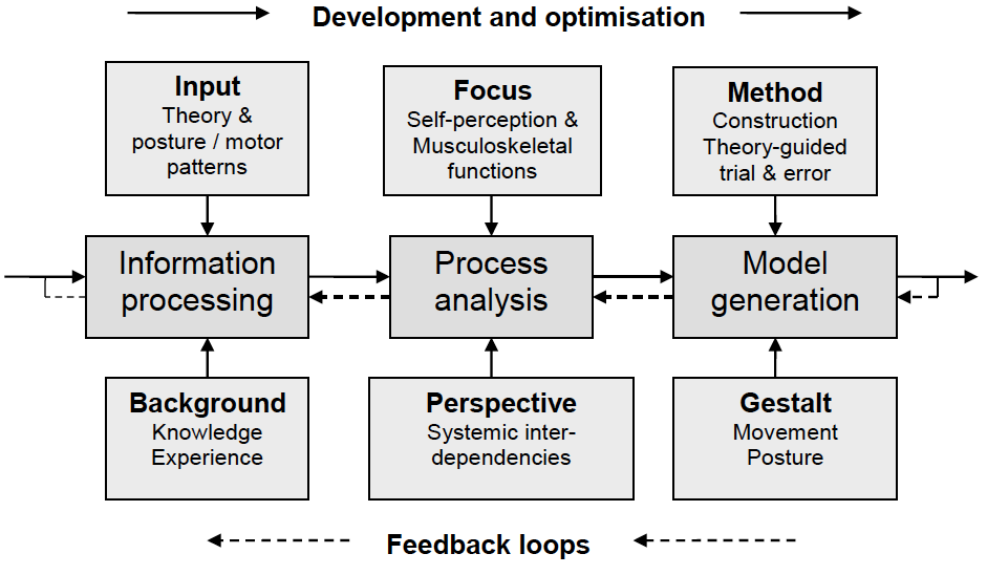

Figure 1: Interactive, analytic and regulatory procedures and repetitive optimisation cycles in action research.

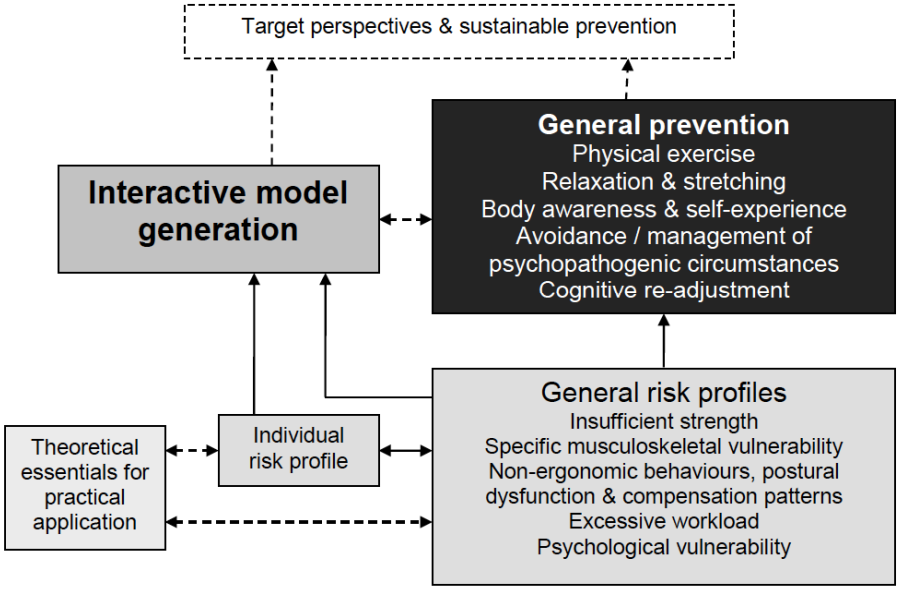

Figure 2: General framework and flow diagram of musculoskeletal risk management in students under COVID-19 conditions and remote learning circumstances.

DISCUSSION

COVID-19 related orthopaedic issues raise a series of urgent questions and sciences are facing complex challenges which require fundamental discussion:

- Orthopaedic problems which are related to the COVID-19 pandemic – such as musculoskeletal discomfort and pain in students in higher education – appear as complex and dynamic entities. Consequently, neither descriptive statistics, *e.g*. mere percentage indicators, nor mono-dimensional input-outcome models are able to represent the whole target system. Transmodal isomorphism between research objects and theoretical models – in other words, the optimised relationship between the real world and its scientific representation – requires adequate simulation techniques.

  By way of illustration, a mathematical functions f(A, B, C) = Y processes three arguments: A, the set of pathogenic parameters such as mental stress or twisted posture, B, the set of relevant personality traits and vulnerabilities such as conscientiousness or predisposition to attacks of mild to moderate tension-type headache, and C, the set of applied preventative strategies and self-regulation techniques such as individualised meditative Karate kata or voice-based emotion-focused coping skills. Y is the value of the function and contains the set of musculoskeletal symptoms.

  The function f itself stands for an algorithm which is tailored to provide an adequate simulation of the examined reality. Creating these algorithms is one of the greatest challenges faced by scientists concerned with scientific representations of dynamic systems. It involves epistemology and correspondence theory of truth and cannot be directly derived from standardised formulae such as calculation of effect sizes. Although standard methods in evidence based medicine are much easier to perform, adequate simulation models are of considerably higher value and it is likely that they define new standards in medical and public health areas.

- A further key issue concerns underlying mechanisms of therapeutic means and processes – and getting to the bottom of curative functions is (probably) of higher epistemological value than mere (statistically processed) comparison of input-outcome data as in regular RCTs, for instance. Understanding underlying mechanisms also helps to avoid typical errors of evidence based medicine, *e.g*. when randomisation masks relevant differences between – erroneously unidentified – subsamples. Particularly interdisciplinary research on underlying mechanisms helps to better understand the patient's reality and to bridge the gap between personalised medicine and theories which stem from inferential reasoning, and hence generalisation.

- Discussing musculoskeletal issues in students under remote learning conditions touches upon an overall issue: How and to what extent should universities provide general and specific health protection and health promotion? The broad spectrum of relevant topics encompasses cardiorespiratory fitness, mental health and musculoskeletal pain in clinically vulnerable students, for instance. In this context, the EU-Russia Digital Roundtable 'New Models of Educational Processes Organization, Novel Educational Practices and Internationalization in the Post-COVID Reality' drew attention to the demands of a 'safe campus' – and this notion also brings concerns of the present article into play.

- The COVID-19 pandemic has brought about considerable sociocultural changes and the broad spectrum of associated public health issues is inextricably linked with both the pandemic itself and related political decisions. The whole situation not only depends on epidemiological parameters but also on political views and has given rise to novel public attitudes towards virus crises. Although it is nearly impossible to realistically predict future public health emergencies, as well as political health-ideologies, it is very likely that the world will be faced with novel – and even more aggressive – health challenges. The question how to get well prepared gains momentum, orthopaedic and rehabilitative perspectives included.

- Moreover, the COVID-19 world has been suffering severe conflicts between medical and political standpoints – and SARS-CoV-2 threat assessment, identification of at-risk population, adequate public health measures and interdisciplinary epidemiology has often become

the cause of bitter argument. Critical voices from medical, sociological and economical areas pointed out that politicians are dealing with a matter they are not familiar with and, consequently, go terribly astray and cause huge multilateral damage. However that be, a strong disagreement between mono-causal political decisions and comprehensive and unbiased medical views is obvious and calls for better communication between medical experts and political decision-makers.

CONFLICT OF INTEREST

None

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