

AN ERGONOMIC REVIEW OF SURGEON'S WORK STATION Part 1

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Abstract: Surgeons' work station comprises the theatre, medical devices, equipment, operating stool and bed and theatre workers. Some of the requirements if not available may lead to discomfort and overtime may lead to fatigue, musculoskeletal disorders etc. The cumulative effect would rub off on the quality of service delivery to the patients both in terms of cost and precision. This paper presents a review of the working conditions of surgeons in the theatre, i.e. the workstation. It suggests that it is worthwhile to pursue affordable (low cost) workstation facilities to enhance surgeons' performance and productivity. Biomechanics and ergonomic principles as well as hygiene factors need to be considered in proposing affordable, efficient workstations for surgeons in order to positively and proactively impact health delivery. This review suggests ergonomic improvement of surgical working condition by proposing a consideration of improved workstation for the surgeon including sit-working of surgeons. This hopefully will impact on the quality of health care delivery.

Keywords: ergonomics, working condition, musculoskeletal disorder, fatigue, surgeons, theatre

1. INTRODUCTION

Surgical operations (SOs) have been part of human healthcare since ancient times. They are carried out by surgeons, i.e. physicians who operate to repair injuries, correct deformities, prevent diseases, and generally improve health of patients [1], using a variety of instruments [2], [3]. They may involve the surgical delivery of a baby by an incision through the mother's abdomen and uterus and have been on since ancient times. [4]. [5]. [6]. [7].

Other common surgical procedures include (i) Appendectomy (ii) Breast biopsy (iii) Carotid endarterectomy (iv) Cataract surgery (v) Cholecystectomy (vi) Coronary artery bypass (vii) Debridement of wound (viii) Dilation and curettage (ix) Hemorrhoidectomy (x) Hysterectomy (xi) Inguinal hernia repairs (xii) Mastectomy (xiii) Neurosurgery among many others.



Fig 1: The extraction of Asclepius from the abdomen of his mother by Apollo [4]

The listed surgical procedures, require mostly the surgeons working long hours [8] with most of the session requiring that he stand-work [2] or being at an improper posture through the duration. Improper postures may be assumed by the surgeon due to the anatomical site he is working on [9]. Various other improper bending of body geometry so as to gain access to some anatomical parts for the procedure on his patient. Continuous or repetitive hand and finger movements and monotonous work task cause neck and shoulder disorders [10]. A correlation has been identified between neck and shoulder pain and the trapezius muscle by [11], [12]. However, the prevalence of people living with two or more long-term health conditions is rising [13].

Fig 2 shows the major anatomical planes of motion and axis of rotation in man. It is envisaged that the motions exercised by surgeon in his work station covers these axes. A proper investigation of how these play out with the biology of the human body is very critical. A surgeon needs all the comfort for his job. Therefore, a review of his workstation parameters vis-à-vis sitting comfort, humidity, temperature, lighting, gear etc. should be precise.

Anyaeche and Lawani [56, and 57] developed an ergonomic score card for evaluating work stations, they suggested environmental and ergonomic factors to include: temperature, humidity, lighting and humidity, acoustic and noise levels. They opine that the characteristics that should be considered in the work environment should include, clearance i.e. head room, leg room, elbow room and access etc.; arm reach which bears on the storage of materials, posture on location and strength. [56] and [56]. These features need to be part of the design considerations for a surgeon's workstation.

These challenges lead to various ergonomic defects such as; musculoskeletal disorders, chronic venous insufficiency, preterm birth and spontaneous abortion, and carotid atherosclerosis [14], [15], [16] and some varieties of blood borne diseases. In addition to the risk of cuts from scalpels and other sharp equipment during surgery, there is also the risk of blood spray [17].

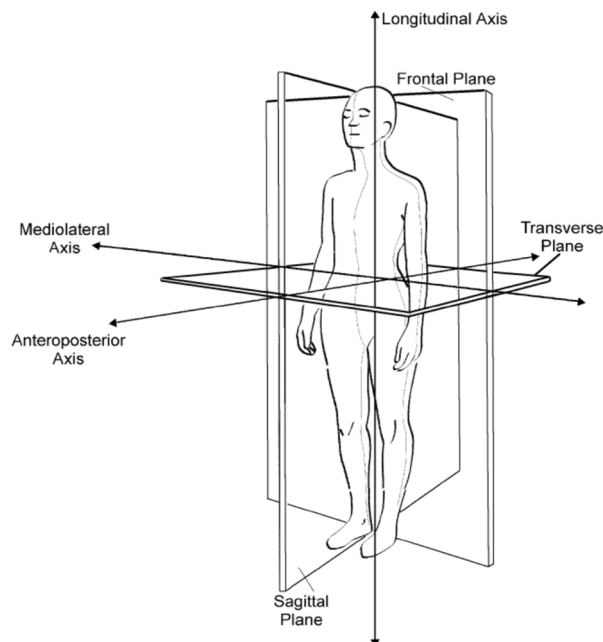


Fig. 2. The major anatomical planes of motion and axis of rotation in man ([58] Source: Knudson Duane, 2007)

2. ERGONOMIC WORKING CONDITION OF SURGEONS IN THEATRE

Ergonomics also referred to as human factor engineering is the scientific discipline concerned with the interactions among human and other elements of a system and it helps to harmonize interaction with people in terms of people's needs, ability and limitations [18]. It is also the scientific study of people at work and incorporates anatomy, engineering, physiology, and psychology and its major aim is to reduce stress and eliminate injuries associated with muscle overuse, bad posture, and repeated tasks [19].

The most prevalent and recurring ergonomic defects in surgeons in the theatre appear to be musculoskeletal pain or injury [20]. Working conditions in the theatre have been found to be quite unfavourable such that medical students demonstrate decreased interest in surgical residencies and resident attrition after entry into the program is reported to be 14% - 20% [21]. Work related injuries are caused by sizable occurrences, local muscle fatigue mostly serve as the signaling defect to musculoskeletal disorders (MSDs) as well as muscle spasms and tremor [6].

Efficient working condition for surgeons is also paramount as they are expected to work to their capacity in performing their job. This is very important because mistakes, no matter how small could risk patients' health [23].



Fig 3: Surgeons often stand-work for long periods [22].

2.1 Possible health defects and their possible risk factors in surgeons

Some causes of injuries among hospital workers which are musculoskeletal injuries, fractures, back injuries, cuts and incision, burns, infections and blood borne diseases[24]. Musculoskeletal disorders, neck pain, shoulder and lower back constitute one of the most common and costly health problems in Europe and North America. Survey conducted by European Commission in 2006, shows about a third of all workers suffer from backache and muscle pain [25]. Studies have also shown that excessive demands on the trapezius, contribute to the CTDs of the neck and shoulders [26]. From another front, international competition spurred an interest in how ergonomic seating and improved postural support can improve productivity [28].

Musculoskeletal injuries/disorders

Musculoskeletal injuries (MSIs) persists as the leading category of occupational injury in healthcare [29] and are very common with performing surgery. Musculoskeletal disorders result from physical stresses that exceed the ability of the body to withstand them without harm and local muscle fatigue is often a precursor of these disorders [6].

Approximately 66 - 94% rate for open surgery [30], [31], [32], [33], [34], [35], 73 - 100% for conventional laparoscopy [36], [37], [38], [39], [40], 54 - 87% for vaginal surgery [41] and 23 - 80% for robotic-assisted laparoscopic surgery. Aaras *et al* [26] found out that risk of musculoskeletal illness increased when loads on the trapezius muscle exceeded 5% of Maximal Voluntary Contraction (MVC) and also a relationship between loads on this muscle and sick leave and pain; further, when forearm support was provided to a group of 20 computer users, pain was reduced. MSDs are common in multimorbidity [42], [43]. The term 'comorbidity' is generally used for any additional health condition(s) occurring at the same time in the same individual as a previously defined index condition [44], [45]. A massive proportion of people with MSDs live with multimorbidity [42], [46].

2.2 Sit and Stand Working

These disorders, (MSD, MSIs), result from cumulative and sustained nature of exposures overtime. Such cumulative effects contribute to varieties of chronic impairments and pain. Effects of such demands, which muscles are subjected to contribute to a variety of chronic impairments although as described by [47]. Kar, and Hedge [48], showed that there is no significant difference in the mean effects of sit and stand working. Other sources have suggested that the muscles of the trunk/hip joint and spino-pelvic curvature and the evaluating muscle activity of healthy adult men while attempting basic standing posture and two postural deviations revealed that postural changes affect activities of the muscle [49].

Lafond *et al* [50], opined that there are negative physical and psychological outcomes associated with prolonged unconstrained standing. MSDs are ubiquitous in multimorbidity because of their high prevalence, shared risk factors, and shared pathogenic processes amongst other long-term conditions and they significantly contribute to the total impact of multimorbidity, having been shown to reduce quality of life, increase work disability, and increase

treatment burden and healthcare costs [44]. Ergonomic working challenges in surgical procedures differ in some distinct surgical procedures.

SOs such as neurosurgery, pediatric surgery, laparoscopy surgery and minimally invasive surgery (MIS) etc., each has its own physical factors affecting the surgeon as highlighted by [51]. Orthopedic surgeon may suffer from a herniated disc after years of pain, finally underwent spine surgery. Or laparoscopic surgeon who, because of the intense physical demands of conventional laparoscopy, altered her practice in favor of other surgical modalities. Oncologists suffer more of chronic back pain from years of hunching over an operating room table, or the gynecologic surgeon who ultimately decided he could no longer perform surgery because of the toll operating had taken on his body [20].

3. POSSIBLE IMPROVEMENTS IN SURGEON WORKSTATION

Although the health defects in surgeons' workstations cannot be completely eliminated due to the nature of their job, the defects can be minimized. Some suggested possible ways to achieve this are discussed as follow;

3.1 Replacing or reducing stand-working with sit-working

A preliminary investigation into the ergonomic condition of surgeons in the theatre suggests that the major cause of the most prevalent and recurring health defect in the working condition could be improper working postures and long hours of stand-working. Working in standing position for a long period of time has been recognized as a vital contributor to decrease workers' performance in industry [15]. Sit-working should therefore be encouraged to reduce the long hours of standing. The use of ergonomic chair that includes some special features such as adjustable height and armrests etc, as well as other desirable workstations parameters.

In advanced economies these and other improved features exist but could be very expensive. If this cost is transferred to the patient then the cost of health care delivery could be negatively impacted. Key elements of an ergonomic operating environment include the height of operating tables and surgical chairs [52]. By this a chair whose relative height is adjustable, and the armrests can be manipulated for various arm loading will be well suited.

The above factors among others, have motivated the need for this study which is a going concern. This pilot effort is an attempt to explore possible road map for more comprehensive investigation and intervention. According to the survey and data collected in this regard, it was found out that surgical bed height fall in the greatest range of 63.5 – 124.5 cm which covers the maximum suggested working height of 76.2 cm. The surgical stool with the widest range was adjustable from heights of 50.8–72.4 cm. This combination of operative table and surgical stool provide a good range of heights [52].

3.1.1 Use of ergonomic theatre chair

Reducing the long hours of stand-working with efficient sit-workable chair, well designed to minimize the load bearing of the hip and ankle should be a welcome idea. Although not all anatomic site to be operated on can be accessed in a sit-working condition, yet a handful of the procedure can be done sitting comfortably on the chair. An affordable, armrest, foot-operated saddle theatre chair is proposed as a possible solution. Azimuddin *et al.*, [52] indicated a template for an ergonomic chair as shown in fig 4.

Many ergonomic advantages are related to the use of armrests [53]. Aaras *et al.* [26], found that the risk of musculoskeletal illness increased when loads on the trapezius muscle exceeded 5% of maximal voluntary contraction (MVC). Recent evidence suggests that activity EE has an important role in dictating lifespan and thus places emphasis on future research to uncover the underlying biological mechanisms [54].

It is of utmost importance that the operating table or bed be considered in the design of the surgeon's chair. It is very important to know the floor-bed height with the clearance of the patient lying on the bed to be operated on. This displacement gives the surgeon the optimal clearance he needs to adjust his chair, which is an important factor in the

design. It may be instructive to note that the surgeon is not alone but working in a team. This need, to satisfy the team, places extra requirements on the design of the workstation.

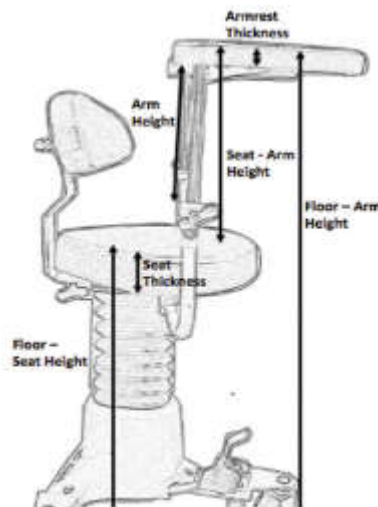


Fig 4: Showing the design dimension considerations of an ergonomic surgical chair [52].

Other important stakeholders working in the theatre include, anesthetic personnel, nurses and others. Other requirements include (i) safety (ii) visible management commitment (iii) consideration of staffs' physique in equipment purchase (iv) allowing for equipment user's opinion and making them feel as being part of the organization (v) the ventilation of the room and (vi) the protective wears he puts on should not be heavy but very safe and protective.

We shall highlight some attempts that have addressed some of the challenges highlighted but the cost remains not fully resolved.

3.1.2 Use of ergonomic theatre bed

An ergonomic theatre chair is best fit for use with an adjustable surgical bed. The bed's relative height can be adjusted to complement the height of the chair.

3.2 Robotic surgery

In recent years, there has been rapid increase in the purchase and use surgical robots in both North America and Europe [55]. This is a well-advanced stretch of technology. In the 1990s, traditional open surgery was challenged by the introduction of Minimally Invasive Surgery (MIS).

With MIS, the surgeon performs operations using 'key-hole' incisions, through which cameras and laparoscopic instruments are passed. This removes much of the abdominal access trauma, resulting in numerous benefits for patients, including less postoperative pain, shorter hospitalization, quicker return to normal function, and improved cosmetic effect [55]. Although the merits of using this method which significantly solved health defects of surgeons, it is also worth mentioning its high cost, possible complications due to patient positioning, specialized training and prolonged duration of surgery. Its advantages remain attractive because it drastically decreased surgical team fatigue, smaller incisions on patient, less post-op pain, less scarring and more [51].

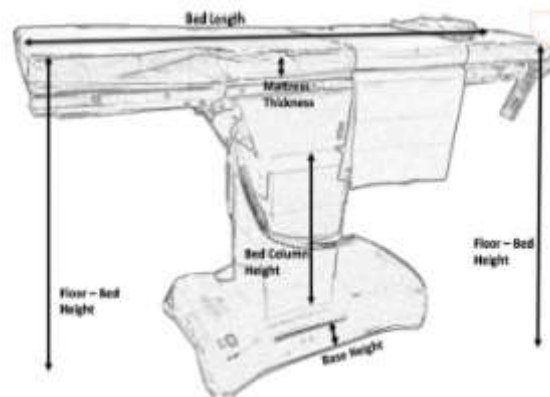


Fig 5: Showing the design dimension considerations of an ergonomic surgical chair [52].

Robotic surgery overcomes some of the limitations of laparoscopic surgery, potentially making the benefits of MIS available to a greater number of patients [55]. Specific problems such as lack of resources and coordination necessities such as restructuring and finally weaknesses in the production of services can be managed with innovative solutions such as of robotic surgery.

4. CONCLUSIONS

Health conditions of surgeons as well as other health workers are very important issues in the health sector cannot be over emphasized. These MSDs and MSIs etc conditions may arise as a result of improper work station setup or abuse. Working condition in the theatre may be a precursor to inadequate healthcare delivery to patients. Musculoskeletal disorders, fatigue and many others may complicate surgical operations. It is considered worthwhile to pursue affordable (low cost) workstation facilities to enhance surgeons' performance and productivity.

This review is presented for ergonomic improvement of surgical working condition by proposing a consideration of improved workstation for the surgeon including sit-working of surgeons. This hopefully will impact on the quality of health care delivery.

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