



HUMAN BODY AND DIGITALIZATION – A MEDICAL PERSPECTIVE

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The creator of digitalization has not been able to keep pace with the created. The concept of digitalization is evolving at an exponential rate and in consequence, the environment that the humans live, has changed at the same pace.

But the human body has not been evolving at that pace. The basic cognitive power, sensory perception and motor abilities of the human being, have changed very little from the hunter gatherer days.

In the digitized environment ...

Hands that were designed for hard labor and vigorous movements are now in static position whilst the fingers are engaged in movement on a keyboard or touchpad. Legs, designed to carry the human body are rested, whilst the rest of the human is taking virtual tours. Eyes that once displayed constant movement to look at objects near and far... bright and dark... are kept constantly in static position staring at blue LED light.

The Human being, who evolved as a social animal is now physically isolated, keeping company of an electronic device. Although he is virtually connected to millions of people trying to process megabits of information that is flowing through digital channels, he is disconnected from reality. This has caused enormous strain on the human body and psyche.

Hitherto unheard of ailments are being discovered, with symptoms that were not associated with known diseases most common to man.

Musculoskeletal disorders such as work related neck pain (WRNP), Computer vision syndrome (CVS), Internet addiction disorder (IAD) are discussed not only by healthcare professionals but also in households whose members are afflicted by such conditions.

In this article, the writer attempts to discuss these issues very briefly and describes certain preventive measures.

Having stated the above, the benefits of digitalization should not be trivialized. That digitalization has benefited medical science and new treatment modalities, thus leading to advancement of science, society and economy immensely is no secret. As such, this article



attempts to highlight some of the benefits that have accrued to medical sciences through digitalization.

Musculoskeletal disorders and computer usage –

Musculoskeletal disorders are conditions which affect soft tissues of the upper extremities and involve the hands, shoulders, neck and arms, and give rise to pain in these regions. Published data reveals that in the US alone, musculoskeletal disorders associated with work have risen dramatically with an incidence of two thirds of all reported occupational illnesses being musculoskeletal disorders related to work ¹

Risk factors associated with work related neck pain (WRNP) are -

1. Female gender (Female computer workers have double the chance of acquiring work related neck pain)²
2. Age more than 30 years
3. Smoking
4. Workers with a previous history of lower back, upper extremity pain.
5. People with higher levels of mental stress. (Another interesting finding is that those having shortage of staff have WRNP and those staff members who have more control over their jobs have less incidence of WRNP).

Primary preventive strategies

Primary prevention refers to promoting of health practices and prevention of disease occurrence before it actually happens.

Primary prevention of WRNP includes adjusting of workstations in such a way that neck flexion does not occur during work, by ensuring correct screen height, use of proper chairs, and taking frequent breaks.

Secondary prevention targets populations who seemingly have the disease, but are asymptomatic. Secondary prevention strategies include identification of individuals having diseases like rheumatoid/osteo arthritis and treating such patients.

Tertiary prevention involves prevention of disability in people who already have symptoms and includes counselling office workers to engage in leisure time exercises like strength and endurance exercises.



It is imperative that individuals who are at the helm of corporate institutions be aware of the risk of potential occupational disorders which could cause corporate losses in terms of sick leave taken by employees as well as decreased work efficiency of those affected by such ailments. Such policy makers should frequently inspect workplaces/workstations to ensure that computers are properly positioned, encourage staff to take microbreaks, which could be utilized to indulge in physical exercise and also advise on avoidance of repetitive activities which could be beneficial for staff in the long term.

Computer vision syndrome (CVS)

A population of approximately 60 million people around the world suffer from computer related vision problems such as dry eye, redness, temporary blurred vision and tired eyes.³ Positioning of the computer screen as well as display quality, glare and radiation, seems to be the cause of dry eye which are known as 'visual effects' of "visual display terminal". Letters on the visual display terminals are made up of dots or pixels whereas those printed on paper are made up of letters with well defined edges which is easy for the human eye to focus on in contrast to pixel characters.

This phenomenon affects not only adults but also children. A study done by University of Berkley in the USA showed that 25 – 30 % of children who use computers needed corrective glasses.

The American Optometrists Association has identified that due to the fact that children have limited self awareness, along with their innate adaptability to problematic vision, they tend to ignore most deficiencies in vision, and are more susceptible than adults to the detrimental visual side effects of computer use. Another factor to be taken into consideration is that adult workstations should not be used by children due to their small size.

Several factors contribute towards the phenomenon of dry eye (which is considered to be a causative factor in computer vision syndrome)

- Reduced blink rate (reduction in the blink rate from approximately 10 to 15 times a minute to significantly lower rate)
- Environmental factors in the workplace such as dry air build up, photocopy toner, dusty environment also play a role.
- Interestingly, it has been observed that when using a computer, there is increased evaporation of tears due to the horizontal gaze and wide opening of eyelids whereas when reading a book, due to the fact that we look down, the lids partly cover the cornea, thus preventing evaporation of tears.
- Office workers who wear contact lenses are increasingly susceptible to computer vision syndrome as the comfort of the contact lenses is dependent on a well lubricated eye.



Computer workers are also more prone to getting tension headaches precipitated by stress which includes anxiety and depression and unsuitable working conditions which include poor lighting, glare, as well as certain eye conditions. ⁴These headaches frequently involve either/ both sides of the head, towards the middle or early part of the day, and are relieved by sleep.

Why do musculoskeletal problems occur in CVS?

Nature has created our bodies in such a way that if our vision is compromised by any means, our body posture will compensate by adjustment so that the vision improves. Researchers have found that computer usage not only places a strain on the eyes, but also does so for head, neck and upper back regions.

Prevention of CVS

Reduction in levels of bright light, thus leading to decreased light being directed either to the eyes or the screen is thought to be beneficial. Windows should have reduced glare and should be covered by blinds or curtains.

In addition to symptoms affecting the eye, extra-ocular symptoms seen in CVS are back, neck and shoulder pain due to bad posture.

The eyes should be positioned approximately 35 to 40 inches away from the computer and the screen 10 to 20 degrees below eye level. Anything above this will cause the neck muscles to strain.

Frequent work breaks with brief walks around the workstation is ideal. The idea is to change focus as well as to relax the eye.

Those who already suffer from dry eyes need to see a specialist who will then prescribe suitable lubricating eye drops.

Laptops and male infertility

It is well known that environmental factors influence the quality of sperm. Smoking, alcohol abuse and certain foods which have spermicidal effects are a few. Another factor to be taken into consideration is raised local testicular temperature. Research has suggested that exposure to laptop computers cause decreased sperm motility and increased DNA fragmentation of sperm giving rise to speculation that laptop computers (which are connected to the Wi-Fi),when placed close to male reproductive organs have the potential of damaging spermatozoa.⁵



It has also been recommended that it is better for men who are interested in becoming fathers, not to carry mobile phones in their pockets for long periods of time as it may too cause damage to sperm.

Internet addiction disorder

Too much of a good thing can be bad, and the ever increasing integration of the internet into varying aspects of our lives have led to the identification of a new addictive behavior , known as internet addiction disorder. This disruptive practice causes neurological, psychological as well as social problems. Such behavior is seen in people who spend hours on the internet doing non work related activities including playing video games.

Recommendations for diagnostic criteria of internet addiction disorder-⁶

1. Internet preoccupation (thinking about previous internet activity and looking forward to next session)
2. Spending increasing amount of time on the internet to gain satisfaction.
3. Making an effort to cut back or stop internet use but inability to do so.
4. Trying to decrease internet use leads to anxiety, depression.
5. Has risked losing a job, relationship, career or educational opportunity due to internet addiction.
6. Lying to family members or others including therapists regarding the extent of use of internet
7. Using internet to escape problems or getting over feelings of guilt, anxiety depression and helplessness.

It is a known fact that addictions activate parts of the brain associated with pleasure – also known as the “reward centre” or “pleasure pathway”. Over a period of time this centre may need increased stimulation to produce a “high”, due to the phenomenon of tolerance, thus making the user show increasingly addictive behaviour.

What is special about internet addiction and associated rewards?

Internet addiction and the rewarding behaviour associated with it has been likened to that of gambling. Activities associated with the internet including chat rooms, social networking sites, e-mail, video games, pornography, give rise to unpredictable and variable rewards. It is said that such rewarding experiences are intensified by mood stimulating content ,such as that found in dating sites (romantic fantasy), online poker (financial) ,internet chat rooms / message boards (sense of belonging), pornography(sexual stimulation).

It has been found that addictive behaviour has a genetic component to it along with the fact that people who display addictive behaviour do not experience the same levels of pleasure that others would find rewarding. There is research being done on the existence of other mental



disorders that can co-exist with internet addiction disorder and these include depression, hostility and anxiety among others.

Overcoming internet addiction disorder (IAD)

Since it is not practical for the internet and its applications to be totally dissociated from the lifestyles of today's society, it is imperative that the sufferers from the above mentioned addictive behaviour be identified and proper treatment given. The following are a list of behavioural changes that can be implemented in addition to seeking professional support to help those suffering to overcome this addiction.

1. Use real events/ activities to help people log off the internet.
2. Using cards to remind the user about detrimental effects of using the internet compulsively.
3. Joining support groups

In addition to these interventions people suffering from IAD are also encouraged to engage in physical exercise. There have also been trials of drug treatment in some cases.

Computer exposure in children - the good, bad and ugly

Computer use and digitalization has , as mentioned earlier in this article, invariably taken hold of the whole family structure of society today, evidenced by the fact that in many households around the world , even very young children have access to a computer and are quite proficient in using it.

Parents buy computers for their children with the good intention of preparing them for the digital age and research has found many positive aspects of computer use in children which include improved fine motor skills, better cognitive development, as well as school achievement and decreased barriers to social interaction.⁷ It is also thought that playing computer games could enhance the ability of a child to read and visualize images in three dimensional space. ⁸

Negative impact of computer usage in children would be-

Inadequate exposure to physical activity (encouragement of a sedentary lifestyle and its associated problems), vision and musculoskeletal problems, sleep deprivation, exposure to unsuitable language and cyber bullying.⁹ Alarminglly, it is thought that playing violent video games can bring about adverse results such as aggressiveness and desensitization of children to suffering.¹⁰ They also make it difficult for a child to differentiate real life from simulation.

The American Association of Pediatrics advises children to spend less time with media, and more time on physical activities like athletics.



Studies also indicate that physical risks associated with computer game playing in children include hand pain, seizures and changes in heart rate. It has been suggested that playing video games can trigger seizures due to “flicker frequencies” or quickly flashing images in patients with photosensitive epilepsy.¹¹

Children are also prone to suffering the same type of musculoskeletal effects as adults and includes injury to wrists, back and also vision problems.

Remedial measures would include proper positioning of equipment, frequent breaks between the computer sessions. Game manufacturers should ensure the production of computer games which have flicker frequencies which are lower than that thought to induce seizures in epilepsy prone children.

Digital medicine

The ability of computers to store information as well as generate information is utilized in the concept of Digital Medicine.

An important consideration in this regard is whether this type of healthcare is universally available - availability to underprivileged, destitute or elderly populations is a cause for concern, also potential patients/ consumers using these services should have utmost confidence that their personal records are confidentially stored. A point to ponder is that whilst it is assumed that government based websites are trustworthy, is it safe to assume that private sites are safe?¹²

An application that uses digital medicine is the **Proteus Discover**, introduced by Barton Health system in the USA, which is an ingestible tablet, within which lies a sensor (the size of a sand grain containing tiny amount of trace elements), which is activated upon contact with stomach acid, and provides information signals to a receiving patch worn on the left upper quadrant of the patients abdomen. The information thus obtained is channeled via wireless transmission to an *i*- phone or smartphone which could be accessed by the patient or his health care provider. Digital medicines also known as “smart medicine”, allows physicians to have a more personalized and interactive approach towards patient care. ¹³

Factors such as poor compliance to treatment, as well as not adhering to proper follow up plays a major role in treatment failure and are addressed by this type of treatment and leads to patient empowerment by encouraging patients to take medication regularly and make positive lifestyle changes.

This type of accessibility could also open new vistas for patients living in remote parts of the world and do not have access to world class health care as well as top quality doctors, who would be easily accessible with such innovations.



The global disease burden of chronic non communicable diseases such as diabetes mellitus, hypertension, heart disease has risen drastically this century and digital medicine is deemed to be useful in dealing with these diseases .This is why digital medicine is a precious find. The fact that most chronic diseases need constant monitoring and as mentioned earlier, lifestyle modification, unlike acute ailments, which can be managed with immediate interventions , interventions can be made via the “Internet of Things”, wearable mobile devices, web based platforms etc, before , during and after chronic disease development thus ensuring a continuum of care for interested parties.¹⁴

Positive aspects of digitalization in medicine

Well before computer based diagnosis was established, much of a clinician’s work and decisions about treatment came through trial and error. Now the scenario has changed and complex treatment modalities are decided by data which is analyzed by computers. The reason behind this is that genetic analysis of the human genome has revolutionized the way people think about treatment and an example of one such technology is the EuResist search engine which uses clinical and genomic data from patients to improve their treatment.¹⁵

Another important aspect of such digitalization is the ability of scientists to create pharmacointeraction network models to predict adverse effect of drugs.¹⁶

It had been said that futuristic predictions of computerized models include “ubiquitous computing or “ambient intelligence” which involves the use of computers in everyday objects.¹⁷ (Embedding of microprocessors in everyday objects which influence individual’s behaviour). Even simple changes in posture could be pointed out by a microprocessor embedded in chairs, thus leading to corrective action by the user. Artificial intelligence has created so much excitement that several science fiction movies like “Artificial Intelligence (2001), Minority Report (2002), Firefly (2002)” have been based on this phenomenon.¹⁸

Looking ahead.....futuristic innovations -

Nanoparticles as drug delivery systems.

As medicine becomes integrated with the latest advances in technology, there is increasing interest in using nano particles as means of effective drug delivery systems.¹⁹ (Especially in diseases like cancer which necessitates targeted drug delivery)

Nanoparticles have a diameter of less than 1000 nanometers and have the ability of travelling through capillaries and also penetrating cells. These particles can carry genes or drugs



which target specific cells (eg - Tumour cells) and be used in treatment modalities of specific disease conditions.

A few examples of experimental models related to medicine are²⁰-

The “Pill Cam”

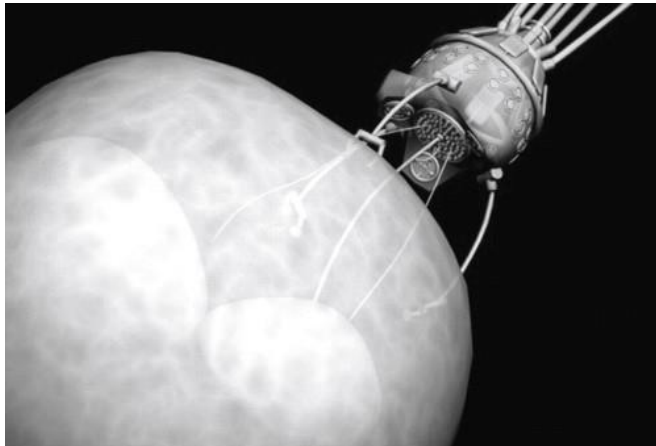
Introduced in the year 2001, this pill sized capsule contains a camera and light, which, when swallowed by the patient, has the ability of travelling through the patients digestive tract and can project images which can be analyzed by doctors. This is a less invasive method as compared to the endoscope which is currently used in the clinical setup.

Nanorobots for diabetes

A novel concept proposed by a research team in Australia suggests the use of nanorobots which travel through the blood stream using the natural flow of blood to detect changes in blood glucose level, which would be a less cumbersome and pain free method for patients to test their blood glucose levels.

Drug delivering microbots for cancer treatment

Another futuristic invention is a drug delivering microbot, capable of delivering drugs directly to its target i.e. the tumour cell, thus preventing the destruction of healthy cells.



*An artist's depiction of a nanobot performing cell surgery.
(Courtesy of Nanotechnology News Network.) <http://www.yalescientific.org/2013/02/microbots-using-nanotechnology-in-medicine/>*



3D printing of organs

3D printing has generated much excitement among the medical community due to the reason that it can be used to replace or enhance certain parts or organs of the human body. This involves the assembly of living cells layer by layer (with or without biomaterials) to create structures which can be used for medical purposes.^{21,22} Researchers have mainly focused on development of tissue such as skin, cartilage, bone, tendon and cardiac tissue and such research aims to fill the ever increasing need of replacement of organs lost/ damaged due to disease or trauma.²³ Concerns related to bio printing is finding suitable 'Bio ink' which is biocompatible and also produce necessary mechanical strength to perform biological functions.

In an article published in the journal "Nature" in April 2015, 3D printing generated an income of US\$537 million in the year 2014 according to Wohlers Associates, a business consultancy firm in Colorado which specializes in 3D printing.²⁴ A company in San Diego already sells tissue to researchers who wish to test drugs for toxicity to liver cells.



*A 3D printed ear which combines biologic and electronic parts
(<http://www.nature.com/news/the-printed-organs-coming-to-a-body-near-you-1.17320#/gallery>)*

Although fully functional organs are yet to make an appearance in the clinical setup due to the sheer complexity of the organs themselves, many scientists are optimistic that they will be able to overcome the hurdles to provide a fully functional liver or kidney to those who desperately need one.

Neurotechnology

In the year 2013, US President Barack Obama pledged US\$ 4.5 billion over a period of 10 years for the "BRAIN initiative" which stands for Brain Research through Advancing Innovative Neurotechnologies (BRAIN),²⁵ and involves identification of all cell types in the brain as well as mapping out neural circuits and their interaction.



In addition to identification of the cellular activity of the brain, this ambitious project aims to develop technology for manipulating the brain which will open up new horizons not only for the treatment of diseases such as Alzheimer's, Schizophrenia, Epilepsy and Autism but also includes development of technology such as the Restoring Active Memory(RAM) Project which aims to develop wireless , implantable neuroprosthetics that help service members, veterans, and others overcome memory deficits incurred as a result of traumatic brain injury or disease.

OBAMA'S BRAIN

The White House has set lofty objectives for its BRAIN Initiative. Now it is up to the participants (purple) to develop a strategy for the programme.

PRIVATE RESEARCH

- The Allen Institute for Brain Science
\$60 million annually
- Howard Hughes Medical Institute
\$30 million annually
- Kavli Foundation
\$4 million annually for 10 years
- Salk Institute for Biological Studies
\$28 million

FEDERAL AGENCIES

(First year funding)

- Defense Advanced Research Projects Agency
\$50 million
- National Institutes of Health
\$40 million
- National Science Foundation
\$20 million

OBJECTIVES

- Provide the knowledge for addressing debilitating disorders.
- Develop new imaging technologies and understand how information is stored and processed in neural networks.
- Understand how brain activity leads to perception, decision-making and, ultimately, action.
- Produce a sophisticated understanding of the brain, from individual genes to neuronal circuits to behaviour.

RESEARCH COMMUNITY

- The National Science Foundation convened workshops to solicit ideas.
- The National Institutes of Health set up a 'dream team' of 15 scientists that is producing reports based on community feedback.

<http://www.nature.com/news/neurotechnology-brain-storm-1.14105>

Some of the cutting edge military applications which highlights the endless potential in the field of neurotechnology are as follows -

- **Brain computer interfaces**

This is based on the concept of conversion of neural activity into input for various communication devices as well as prosthetics. The Cognitive technology threat warning system is able to, via a portable binocular, "convert subconscious, neurological responses to danger, into consciously available mechanism".²⁶



- **Warfighter enhancement**

Includes research into development of “in-helmet ultrasound transducers capable of stimulating neural circuits”

- **Neuroscientific deception detection and interrogation**

“Brain fingerprinting” utilizes the EEG (electroencephalogram) to identify “Concealed information”. fMRI based lie detection services are being marketed by several companies and include No Lie MRI and has the ability of differentiating between truth telling and deception.

Although both positive and negative aspects of the digital revolution have been identified and continue to be debated upon, it is up to discerning individuals to decide on the beneficial aspects and take corrective or precautionary measures for the negative features described above. It should be observed that humans should take control of digitization as the concept appears to be a bad master but a good servant.

(Disclaimer: The foregoing is not a comprehensive study of the concept described therein, but a mere discussion of the factual evidences available on the concept of digitalization from a medical perspective. The contents should not be construed as medical advice. Any views or opinions presented herein are solely those of the author and do not necessarily represent those of her employer.)

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