Investigation of the Effect of Individual Metabolic Differences on Workers Musculoskeletal Disorders

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ABSTRACT

Evidence that workers have suffered from Musculoskeletal disorders (MSDs) has been noted as far back as 1713, though was known by different names, e.g. writer's cramp, repetitive strain injury (RSI). These days, students and office workers, who use computer and mobile phones are suffering from it along with process and factory workers. Every year millions of workers are suffering from MSDs. Low productivity, workers' compensation and other costs due to MSDs are costing billions of dollars every year to employers and governments. Some workers are susceptible to one type of MSDs but not others, despite performing the same repetitive work. This has surprised management and researchers. Researchers have not considered workers' metabolic types in analysing their research, although correlation between health problems, repetitive work and metabolic types of the workers was reported in 1875. Three metabolic types: ectomorph, mesomorph and endomorph have distinct physical, physiological and psychological traits. The purpose of this research is to find the reasons why some workers are susceptible to one type of MSDs and others are not. By understanding that, it will be possible to develop a strategy to prevent MSDs by studying input, throughput and output. Metabolic types explain why some workers are susceptible to one type of MSDs and others are not, despite performing the same work.

Keywords: Repetition Strain Injuries (RSI), Repetitive Strain Injury (RSI), tenosynovitis, carpal tunnel syndrome, metabolic types

INTRODUCTION

Musculoskeletal disorders (MSDs) is an umbrella term for tenosynovitis, epicondylitis, carpal tunnel syndrome. MSDs is known as carpal tunnel syndrome and cumulative trauma disorder in the United States, occupational cervicobrachial disorder (OCD) in Japan and repetitive strain injury (RSI) in the United Kingdom and Australia. In Australia it is also known as repetition strain injuries (RSI) (Refer Stevenson (Ed.), 1987).

Generally MSDs sufferer's pain is caused by the problem in the musculoskeletal or nervous system. Additionally, problems in the nervous system may cause problems in the musculoskeletal system with time and vice-versa. This may be the reason that some suffers told the author that they felt muscular pain, numbness and/or tingling. Most MSDs sufferers consult doctors at the later stage (Stage III) and hence likely to have musculoskeletal and nervous system disorders. This may create problems to diagnose the root cause and hence proper treatment to cure MSDs sufferers may be difficult.

In the past, factory and process workers suffered from MSDs. But now most students and office workers are using computer for more than five hours a day. Due to this process they are also suffering from it. 58% of academic staff

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and students in Australia suffered from computer related pain (Sawyer, 2004). 80% of ACT public servants (Australia) suffered from MSDs (Strazdins and Bammer, 2004). 79% of managers and senior executives experience neck pain in six government departments and 75% of all participants reported shoulder pain in Australia (Griffiths et al., 2012). Text messaging in mobile phones involves similar muscles as sending a telegram. Hence one should not be surprised to see telegraphist's cramp or de Quervain's disease amongst frequent user of mobile phone.

COST OF MSDS

The total cost of work-related injury and illness caused by body stressing during 2008-09 was $25.2 billion in Australia (Safe Work Australia, 2012). The U.S. Bureau of Labour Statistics estimated 700,000 workdays are lost annually because of MSDs, costing employers $15-20 billion per year in workers' compensation (Burke and Peper, 2002). There are direct and indirect costs to the employers due to MSDs. Direct cost includes workers' compensation, loss of production due to absenteeism and labour turnover; indirect cost includes inefficiency due to the MSDs, inefficiency due to low morale as a result of MSDs and industrial problems due to MSDs (Baidya and Stevenson, 1982). If we add similar costs around the world, it will be thousands of billions of dollars per year.

Low productivity and high insurance cost due to MSDs have increased the cost and triggered the management of many industries, e.g. banking, manufacturing and telecommunication, to take the drastic step of outsourcing problematic work to countries where labour cost is cheap, and health and safety standards are relaxed due to the over supply of workforce. In Australia, clothing factories like Speedo and Bonds, and food processing factories like Rosella and Heinz, have closed down due to higher labour cost. These types of industries are major contributor of MSDs (Baidya and Stevenson, 1982; Baidya and Stevenson, 1985). The manufacturers and big chain-retailers have outsourced the garment production to Bangladesh because of cheap labour cost. In April 2013, a garment factory building collapsed in Bangladesh, which killed 1135 people. MSDs may have had a hidden hand in this accident. 42,400 American factories closed down and lost 5.5 million manufacturing jobs since China joined the World Trade Organisation in 2001 (Mccormack, 2009). Without an industrial base, country will depend on foreign manufactures and the national trade deficit will continue to grow. This may have happened in Portugal, Italy, Greece and Spain. It will be worth studying whether MSDs have a contribution to the present high unemployment rate and financial problem in those countries. If it has, alarm bells should be ringing for other developed countries.

MSDS AND METABOLIC TYPES

It is well known that the constant repetition of any one act is liable in persons of a certain constitution to bring about a disability to perform that act (The Lancet, 1875). Even in 1875 it was believed that certain constitution or metabolic types were over represented in disability due to certain type of repetitive work. This suggests a correlation between the health problems, type of repetitive works, and the metabolic type of the workers. While the author was doing work-method study in factories in Sydney during 1982-83, management used to ask why some workers got MSDs and others did not, despite doing the same work under the same conditions. During 1983-84 the author did a survey among the MSDs sufferer and control groups to find why some were susceptible to MSDs and others were not. At that time he could not conclude why. When he observed the same data considering different metabolic types, it became clear why some were vulnerable to MSDs and others were not e.g. higher percentage of the control group in that survey drank alcohol at least once a week in moderation compared to the sufferer group ($P=0.0001$, $n > 100$ in both groups) (Baidya, 1986). Some workers will have acidic tissue, others will have neutral tissue and still others will have alkaline tissue depending on the metabolic types (explained below). Furthermore, repetitive work might have accumulated lactic acid in the tissue. Hence drinking alcohol in moderation once a week may have neutralised the tissue.

OBJECTIVE

The objective of this research is to study different metabolic types and see whether that will help to explain why some workers are susceptible to one type of MSDs while doing certain type of repetitive work and others are not, despite performing the same work. Understanding why they are prone to MSDs, it may be possible to develop a strategy to prevent millions of workers around the world from MSDs and save billions of dollars to employers and governments by studying input, throughput and output.

METABOLIC TYPES

Humans are divided into sympathetic dominant, sympathetic/parasympathetic co-activation and parasympathetic dominant in neurological studies. Similarly, human embryos are classified into: ectomorph, mesomorph and endomorph. Ayurveda (an ancient traditional treatment in South East Asia) also divided humans into three categories, i.e. Vata, Pitta and Kapha. Characteristic differences of three types of humans (Metabolic types) in different types of studies are shown in Table I below.

Table I: Human types (Metabolic types) in different studies. (Source: Thompson, 2001)

Studies	**Metabolic Type I**	**Metabolic Type II**	**Metabolic Type III**
Ayurveda	Vata	Pitta	Kapha
Embryological	Ectomorph	Mesomorph	Endomorph
Physiological	Catabolic	Transformational	Anabolic
Neurological	Sympathetic dominant	Sym/Para co-activation	Parasympathic dominant
Chemical	Tissues acid	Ionic balance	Tissues alkaline
Psychological	Enthusiastic, anxious/fearful	Aggressive, determined	Calm, peaceful, lethargic
General physique (Body types)	Lean/thin,	Muscular, medium build	Stout/heavier
Food	Problems with protein metabolism	Problems with fat metabolism	Problems with carbohydrate metabolism

However, all humans may not have all the characteristic of Metabolic type I, or type II or type III. Some humans may have some characteristics of Metabolic type I, some of type II and some of type III. Ayurveda realised that and hence stated that there will be humans who will be Vata-Pitta-Kapha, Vata-Pitta, Pitta-Vata, Vata-Kapha, Kapha-Vata, Pitta-Kapha and Kapha-Pitta. Similarly there will be Metabolic type I-II, Metabolic type II-I, Metabolic type I-III, Metabolic type III-I, Metabolic type II-III, Metabolic type III-II and Metabolic type I-II-III. For simplicity, the author will concentrate on Metabolic type I, Metabolic type II and Metabolic type III only in this paper.

Ectomorph, mesomorph and endomorph develop into the human physique of different physical, physiological and psychological characters. These differences are written below.

PHYSICAL DIFFERENCES

Ectomorphs are very tall or short. They will have narrow shoulders and hips, unusually short or long arms and legs, and also long tapering fingers. They will have natural leanness of the body. Mesomorphs will have medium to broad frames and shoulders with medium hips, arms, legs and fingers. They can maintain average weight. Endomorphs

will have medium to broad frames with wide shoulders and hips. However, fingers and toes will tend to be short. They will gain weight easily especially in the lower parts of the body, e.g. rear end and thighs.

PHYSIOLOGICAL DIFFERENCES

Ectomorphs are likely to have colder bodies (e.g. hands, feet). The muscle and tendon fibres will be uneven and acidic. They will have drying nature. Mesomorphs will have a hotter body and neutral (a balance acid-alkali) muscle and tendon tissues. They will be very energetic and often use big muscles. Endomorphs will have alkaline tissues and will have more fluid in the body including synovial fluid. They are likely to have extra waste, e.g. fat, mucus and phlegm, in the body and hence may be obese.

Table II: Characteristic of Ectomorph and Vata. (Source: Thompson, 2001)

No	Ectomorph	Vata
1	Delicate build	Underdeveloped build
2	Stooped shoulder	_
3	Prominent joints	Prominent joints
4	Narrow flatter chest	Narrow flatter chest
5	Long, lean legs	Cold hand and feet
6	Spare, angular frame, thin	Angular frame, thin
7	Sharp	Quick understanding
8	Hyper-reactive to stimulants, unpredictable	Restless, active, spontaneous
9	Sensitive to pain	Sensitive, imaginative
10	Poor sleep habits	Poor sleep habits, frequent insomnia
11	Chronic fatigue	_
12	_	Dry hair and skin

Table III: Characteristic of Mesomorph and Pitta. (Source: Thompson, 2001)

No.	Mesomorph	Pitta
1	Large skeleton	Average build
2	Broad shoulder, wide chest	Medium frame
3	More muscles	Muscular
4	_	Moderate weight
5	Energetic, active in sport	_
6	Good coordination	Sharp and critical
7	Adventure loving	Courageous
8	Assertive	Aggressive
9	_	Intelligent
10	_	Good appetite

Table IV: Characteristic of Endomorph and Kapha. (Source: Thompson, 2001)

No.	Endomorph	Kapha
1	Large frame	Large frame
2	Thick neck	_
3	Large (wide) hand	_
4	Rounded contours, round face	_
5	Tend to weight around abdomen	Carry more weight
6	_	Gain weight easily
7	Calm, even temperament	Calm, disposition
8	Relaxed posture, high stress tolerance	Peaceful
9	Slow emotional response	Receptive and open
10	_	Content
11	_	Sentimental, can become attached

12	Need affection & approval	_

PSYCHOLOGICAL DIFFERENCES

Ectomorphs will be anxious and fearful by nature and will worry about trivial matters. Mesomorphs will be aggressive, impatient and arrogant. They are likely to be extroverted. Endomorphs will be calm, forgiving and loving and are likely to be introverted.

Characteristics of ectomorph, mesomorph and endomorph are similar to that of Vata, Pitta and Khapa (in Ayurveda) respectively (Thompson, 2001). These are shown in Table II, Table III, and Table IV above.

METHODOLOGY

The author started the RSI sufferers' support group in Sydney, Australia. Meetings were held four times a year. During the meeting the members were encouraged to discuss amongst themselves about their work, their work and family environment and their treatment types. The author observed that inflammation related MSDs sufferers have certain type of characteristics, whilst nerve related MSDs sufferers have different type of characteristics.

Questionnaire Design

A questionnaire was designed on the basis of the author's observations, member's discussions and the author's previous experience in questionnaire design for RSI survey. There were questions related to (a) personal information, (b) work related, (c) physical activities before they suffered from MSDs, (d) general health, (e) support from family members and friends, (f) habits and (g) others i.e. diet, family health history and effective treatment.

The questionnaire was tested among the members of RSI sufferers' support group. It was amended where necessary, so that the subjects could understand the questions easily.

Subjects

The author requested "RSI and Overuse Injury Association of the ACT Inc. Canberra" and "Occupational Overuse Support (New Zealand) Inc." to distribute the questionnaire to their members. Members of RSI sufferers' support group were not included in this survey as they were used to design the questionnaire. Seventeen questionnaires were returned.

RESULTS

The number of subjects participated in this survey is very small. Therefore statistical analysis has not been performed. Only personal information, health, effective treatment and work type are used in this paper and shown in Table V below.

To assign metabolic type accurately, the physical, physiological and psychological nature of the subject needs to be analysed. Physical feathers like nose, eyes, hands, arms, height and weight are included along with physiological and psychological nature to differentiate metabolic type in Ayurveda (Refer Baidya, 2012 for a questionnaire to fully evaluate Metabolic type of a person.). However, in this research only general physique (body type) is used to differentiate Metabolic types and assumes other characteristics shown in Table I are true. He assigns "Metabolic type I" to the subject who has Body Mass Index (B.M.I.) less than 26 (Calculation of B.M.I is shown below.), "Metabolic type II" to the subject who has B.M.I. 26 to 30 and "Metabolic type III" to the subject who has B.M.I. more than 30.

There are only two male subjects (12%) compared to 15 female subjects (88%). This study indicates that more females suffer from MSDs in comparison to males. Male subjects are older compared to female subjects when they first suffered from MSDs. The mean age of male subjects is 55.5 years and that of female subjects is 40 years. The mean age of female Metabolic type I, Metabolic type II and Metabolic type III are 42, 32 and 35 years respectively.

Table V: MSDs sufferers' Physical characters, Metabolic types, Health problem and Treatment

No.	Sex	Age when suffered	Height (M)	Weight (Kg)	Elbow to finger tip (cm)	Hand length (cm)	B.M.I.	Meta-bolic type	Work type	First affected body part	Health problem	Treat-ment
1	M	61	1.92	94	47	19	25.5	I	-		Numbness, tingling	Walking
2	M	50	1.54	60	37	16	25.3	I	Typing	Elbow		Exercise
3	F				41	7.5*			Typing	Palm, finger	Numbness, tingling	Rest
4	F	37	1.52	47	-	-	20.0	I	Typing	Back, arm	Numbness, pain	-
5	F	48	1.60	51	43	17.5	20.0	I	Lab	Hand	Pain	Rest
6	F	28	1.77	50	45.5	19	16.0	I	Typing	Forearm	Numbness, pain	Rest
7	F	51	1.68	64	40	16	22.4	I	Typing	Wrist	Tingling, pain, swelling	Joint mo-bilization
8	F	45	1.65	65	41	8*	23.9	I	Lifting	-	Tingling, pain	Rest
9	F	-	1.69	56	44	18	20.0	I	Typing	Hand	Tingling, pain, cold	Rest
10	F	-	1.69	69	-	-	24.0	I	Typing	Forearm	Tingling, pain	Massage
11	F	30	1.65	72	38	17.5	26.0	II	Typing	-	Teno-synovitis	Swim
12	F	35	1.69	82	43	18.5	29.0	II	Typing	Wrist	Numbness, pain	Joint mo-bilization
13	F	31	1.85	100	-	-	29.4	II	Cutting	-	Pain	-
14	F	29	1.70	98	42	8*	34.0	III	Typing	Elbow	Tingling, swelling	Rest
15	F	32	1.60	89	40.5	-	35.0	III	Typing	Shoulder	Tingling, pain	-
16	F	35	1.63	84	-	--	31.6	III	-	-	Tingling, pain	Herbs
17	F	45	1.67	Vow	43	8.5*	-	III	Typing	Forearm, hand	Tingling, pain	Rest

Vow= very over weight; * = incorrect measurement

The mean height of Metabolic type I, type II and type III are 1.66 metres, 1.73 metres and 1.65 metres respectively. Similarly the mean weight of Metabolic type I, type II and type III are 61.7 kg, 85 kg, and 90 kg respectively. Body Mass Index (B.M.I.) is calculated by dividing weight (in kg.) by height (in metre) square.

Length from the elbow to the tip of middle finger of the subjects in this survey varies from 37 cm to 47 cm. Metabolic type I subjects have extreme values, i.e. 37 and 47 cm. This is expected as Ayurveda describes that Vata (Metabolic type I) will have very long or very short arm length. The mean arm length of Metabolic type I is 42.5 cm, where as that of Metabolic type II and III are 40.5 and 41.8 cm respectively. This shows that Metabolic type I has longer arms in comparison to Metabolic type II and III. Finding of this research supports Ayurveda's theory that Vata (Metabolic type I) will have longer arms compare to other types.

Some of the subjects did not understand the "hand length" question and gave incorrect measurements or did not answer that question. Hence that data has been ignored.

80% of the subjects (who answered this question) were typing in their work before they suffered from MSDs. First affected part of the body of all female Metabolic type I subjects are forearm, wrist or hand. However 50% of Metabolic type III reported that the joint is the first affected part of the body.

Five (50%) of Metabolic type I subjects suffer from tingling, three (30%) suffer from numbness and six (60%) suffer from pain. Similarly all four (100%) of Metabolic type III subjects suffer from tingling, three (75%) suffer from pain and one (25%) suffers from swelling. Rest is the best treatment for 50% of the subjects (who answered) and exercise, e.g. walking, swimming, joint mobilization and massage, is the best treatment for 44% of the subjects.

Although the number is not large, the survey results reinforce the observation made by the author among the members of RSI sufferers' support group. Hence, this research encourages further research dividing the workers into three metabolic types.

DISCUSSION

This research shows that more females suffer from MSDs in comparison to males as shown by other researchers. However, this trend may change as more workers and students are using computers for more than five hours a day and mobile phone in texting messages, unless MSDs is due to physiological difference between males and females. Metabolic type I subjects were relatively older than other types when they noticed MSDs problem.

The mean height of mesomorph (Metabolic type II) is relatively greater than that of others, while the mean weight of ectomorph (Metabolic type I) is the lowest and that of endomorph (Metabolic type III) is the greatest. This suggests that Metabolic type I is lean and Metabolic type III is heavier compared to Metabolic type II. This finding supports the general physique (body type) of Metabolic types as shown in Table I.

Metabolic type I subjects have extreme elbow to the tip of middle finger length. They have longer arms in comparison to Metabolic type II and III subjects. Findings of this research supports Ayurveda's theory that Vata (Metabolic type I) will have longer or shorter arms and fingers compare to other types.

All subjects except three (one was doing lab work, another doing cutting and still another doing lifting work) were typing before they suffered from MSDs. Therefore they were doing the same type of work. They suffered from pain, numbness and/or tingling. However, the first affected part of the body varies.

The back, hand, wrist and forearm are the most affected parts of the body of female Metabolic type I. This may be due to their work posture, their individual preference or due to furniture and equipment. Since employers supply standard furniture and equipment to the workers, which may not be suitable to some workers as they have different body types. Ectomorphs (Metabolic type I) will have extreme physical characters (anthropometric measurement), e.g. longer or shorter limbs as demonstrate in this survey. Tools, machines and furniture are designed to suit medium size people. Therefore, standard sized tools, machines and furniture without proper adjustment method for the workers may not be suitable for them. Using unsuitable tools, machines and furniture may compress the nerve and cause nerve related problems.

According to Ayurveda (e.g. Mehta et al. 2002), Vata (Metabolic type I) will have cold extremities. The conduction velocity of the impulse signals in the nerve will be low due to a lower limb temperature (Henriksen, 1956; Braddome and Schuchmann, 1980). Thus, they are likely to suffer from nerve related problems than other types especially if they are working in cold places, e.g. in an air-conditioned environment. Nervous system disorders are prevalent in Vata type (Thompson, 2001).

The median nerve is connected to the middle of flexor carpi radialis muscle at the forearm and to the thumb, index, middle and ring fingers. The activity of that muscle/tendon will be high due to frequent repetitive movement of the fingers during work like typing. But the velocity of the impulse signals in the median nerve will be low for Metabolic type I. Since the demand is greater than the supply of the impulse signals, some of the workers' motor endplate {where axons (nerve fibre) join the muscle fibre} may have been damaged, which causes tingling. Other workers' axons near the motor endplate may have been damaged and consequently they feel numb. These may be the reasons that most Metabolic type I in this survey suffered from numbness and tingling in the extremities.

Metabolic type I people may have cold extremities due to reduced blood flow and may also have a lower amount of haemoglobin in the blood. This may explain the "chronic fatigue" character of ectomorphs that is shown in Table II.

Another reason for the chronic fatigue may be due to low blood sugar level. Blood sugar is converted to pyruvic acid, which reacts with oxygen to produce carbon dioxide, water and adenosino triphosphate (ATP) (ATP stores energy). People with a high protein and fat diet have lower blood sugar concentration and fatigue (exhaust) earlier during exercise in comparison to people with carbohydrate diet (Bergstrom et al., 1967). This could explain the protein metabolism problems that is characteristics of Metabolic type I that is shown in Table I. As local muscle fatigue is a precursor of MSDs, further studies can examine whether Metabolic type I people have lower haemoglobin and/or lower blood sugar. People with lower haemoglobin may use an iron rich diet to improve their MSDs related health problem. Low blood sugar level people may use a carbohydrate-rich diet to help improve their MSDs related health problem.

Metabolic type II (mesomorph) may suffer from inflammation (Thompson, 2001). The author's observation among RSI supporter's members (mesomorph type) supports this. In this survey one (33%) of Metabolic type II subject suffers from tenosynovitis.

Metabolic type III (Kapha) people will have edema, extra mucus and fat in the body and hence will be heavy compared to other types as reported in Ayurvedic literature (e.g. Mehta et. al. 2002). During repetitive movement of the hand and arm, e.g. typing, drilling machine operation, fat deposited near the joint (e.g. elbow) will push the synovial membrane. Since this type of people have more synovial fluid and fat in the body compared to other types, the repetitive push and pull of synovial membrane will tear the membrane due to pressure from both sides (fat and synovial fluid), causing synovial fluid to leak. This will cause swelling and pain at the joint. Fat may also press the nerves during repetitive movement. Thus this type of workers may also sufferer from tingling or numbness at the middle of the forearm as the median nerve is connected to the flexor carpi radialis muscle (at that location) and also connected to the thumb, index, middle and ring fingers as written above. This shows that the same work (in this case typing) can cause various types of health problems at different locations (in this case pain and swelling at the elbow and tingling or numbness at the forearm and fingers) to Metabolic type III.

Metabolic type III people will have more mucus in the body compare to type II and III as written above. The mucus may accumulate at the nasal and throat passage obstructing free flow of air (oxygen). This may cause a reduction in air flow, leading to a shortage of oxygen when converting blood sugar to ATP. This may be a possible explanation of the lethargy and the problems associated with carbohydrate-rich diet, which is characteristic of Metabolic type III as shown in Table I. Thus this type of people is likely to have higher blood sugar level. Further studies can conform whether Metabolic type III people have higher blood sugar level and also whether they have lower oxygen consumption compare to other Metabolic types.

CONCLUSIONS

Humans (workers) are divided into three metabolic types. Each metabolic type has distinct physical, physiological and psychological characters. The same work can cause various types of MSDs at different parts of the body to different Metabolic types.

Repetitive work that is performed for a long duration (say 5 hours or more) may give following types of MSDs to different metabolic types:

(a) Ectomorph (Metabolic type I) is likely to suffer from nerve related MSDs.
(b) Mesomorph (Metabolic type II) is likely to suffer from inflammation related MSDs.
(c) Endomorph (Metabolic type III) is likely to have pain at the joint and also likely to compress nerve at the joint. Hence they are like to suffer from pain, swelling, numbness and tingling.

This illustrates the complexity of MSDs, which have been a challenge to the researchers to solve, but need to be solved as these problems are costing billions of dollars to employers and governments every year.

FUTURE RESEARCH

To solve MSDs once and for all, this pilot study suggests research with thousands of suffers and control subjects to determine the validity of the conclusions presented in this research. Such research will be feasible by performing multinational research coordinated by one organisation. It is important to establish an international organisation to coordinate the multinational research activities so that researchers will be on the same path. This way, resources will be centralised and multinational data collected can be analysed efficiently and effectively. Once this is achieved, it will be possible to develop a strategy to prevent MSDs by studying input, throughput and output.

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