Predictive Modelling of Musculoskeltal Disorder in Shoulder Musculature Among School Students: Case Study, Kangra, Himachal Pradesh, India

Engineering

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ABSTRACT

This study is designed to analyse the effect of mass and type of school bag on shoulder musculature among school going children of age 10-14 years. This work consists of two phases. In first phase questionnaire based study was conducted on 70 students in three schools of Kangra, districts of Himachal Pradesh. Visual Analog Scale was used for pain rating. It was found that 25 persons have had significant shoulder pain. Using these 25 data Artificial Neural Network has been trained with the help of Feed Forward Back Propagation Technique. Type of backpack and ratio of backpack weight to the body weight of school going children were considered as input variables, however pain generated in shoulder was taken as output variable. Further a predictive model was developed after training the network. Backpack with wide padded shoulder and padded back was found to be significant in reducing the shoulder pain through both the observed and predicted value.

INTRODUCTION

Bags are the appropriate way to carry load safely and more conveniently [1]. In India the different types of school bags that are used by children to carry occupational load. In this study School bags are divided into three different types, Backpack with wide padded shoulder straps, Backpack with tight narrow shoulder straps without padding and Backpack with wide padded shoulder and padded back. Prolonged use of excessively heavy schoolbags contributes to the development of early musculoskeletal disorders, as well as establishes a vulnerability to developing a MSD later in life [2]. Risk factors for musculoskeletal discomfort associated with schoolbag carriage include the combined effects of heavy loads, load shape and size, time spent carrying the load and position of the load on the body [3]. Different researchers shows that carrying heavy load causes musculoskeletal pain [5,11,7]. There is a widespread belief that repeated carrying of heavy loads, such as school backpacks, place additional stress on rapidly growing adolescent spinal structures, making them prone to postural change [4].Adolescence age is critical developmental stage regarding musculoskeletal development. Children buckling underweight of heavy and poorly designed school bags. Backpack should weigh not more than 10% of the child's body weight [1] and it should be worn over both shoulders so the weight is distributed correctly across the back. It is reported that musculoskeletal symptom in school going children is multifactorial in origin. The carriage of heavy school bag is one of the suspected factors for it [12]. Moreover, external forces such as load carrying may also influence the growth, development and maintenance of the alignment of the human body [6].Prevalence of back and neck pain was approximately 50%; 53% of females reported neck pain compared with 44% of males (p < 0.01). Almost half of participants carried their school bag for more than 30 minutes per day with 85% carrying their bag over both shoulders. School bags were found to be heavy by 54% and to cause fatigue by 51%.It has been concluded in the study that, neck pain is also very common as back pain between adolescents. Study demonstrate association of back pain and neck pain with school bag load, duration of carriage and method of transport to school[8]. The mean schoolbag weight was found 6.2kg, 68% of the schoolbags weighed >10% body weight. The mean percentage body weight carried in schoolbags was 12%. The majority of students used backpack-style schoolbags (95%), but only 65% carried them on their back over two shoulders. The reported discomfort was higher for girls (80%) than boys (63%) on the initial questionnaire, but over the study period, equal numbers of boys and girls reported discomfort due to carrying their schoolbags (59%). Girls reported fewer areas of discomfort but higher VAS intensities than boys[9]. Another study shows that mean bag weight carried by the urban school children are 7.1 kg which is 17% of their body weight and rural school children are 3.2 kg which is 12% of their body

weight. Among the urban school children(n=201) 62.3% of them are having pain due to backpack out of that 42.55% are having shoulder pain and 19.8 % have back pain. In comparison with rural school children it is only 17% of which 11.4% with shoulder pain and 6.2% with back pain[10]. A cross sectional study of 237 sixth-graders in Milan, Italy it was observed that backpacks of children were heavy (79%), caused fatigue (65.7%), and caused back pain (46.1%). No significant difference between genders was detected [11]. Schoolbag weight for third form students (mean age 13.6 years) was 13.2% of their body weight, while for sixth form students (mean age 17.1 years) it was 10.3% of their body weight. These weights may exceed the recommended guideline load limits for adult industrial workers. Musculoskeletal symptoms were reported by 77.1% of the students. Symptoms were most prevalent in the neck, shoulders, upper back and lower back [12].

Load carried by healthy male school children (n=200), mean (SD) age 12.5 (0.5) years, from high schools in Mangalore, India found to be 15% of body weight which changes all the postural angles (cranio-vertebral, head on neck, head and neck on trunk, trunk and lower limb) in preadolescent children.

The CV angle changed significantly after 15% of backpack load ($P < 0.05$). The head on neck (HON) and head and neck on trunk (HNOT) angles changed significantly after 10% of backpack load ($P < 0.05$). The trunk and lower limb angle also changed significantly after 5% of backpack load ($P < 0.05$).Study shows that Carrying a backpack weighing 15% of body weight change all the postural angles in preadolescent children. [14] The study shows that weight carried by school children is much more than the prescribed limits. It can be seen through above mentioned findings that MSD takes place in both the shoulder and back; however **S. Dockrella** reported that overall 65% of the discomfort was in the shoulder. Hence shoulder pain is prioritised over back pain in this study. Further it has also been observed that very few works have been reported regarding development of mathematical or predictive model. In addition to that no work has been reported the modelling technique with ANN as far as authors knowledge. Keeping these views attempt has been made by authors to develop a generic predictive model with the use of Artificial Neural Network.

DEFINITION OF THE PROBLEM

In this research School going children were asked about pain generated during carriage of bag pack. A case study of Kangra, Himachal Pradesh India was taken for the study. 25 school going children were given a questionnaire regarding shoulder pain. VAS was used to rate pain. Using this result a input-data has been framed and presented in Table1 .the input variables are ratio of bag weight to the ratio of body weight and type of

backpack carried by school children however output variable is pain generated in shoulder pain. It is to be noted that school children of age group 10-14 has been considered for the study.

SOLUTION METHODOLOGY
1.1 Artificial Neural Network
Artificial neural network imitates the learning activities of human brain based on operation of biological network [15]. Artificial neural Network is an emerging tool especially to predict the process variables in manufacturing as well as industrial Engineering. It has an edge over other modelling technique due to simplicity. The time in association with predicting new values of output was also found to be very less. Near about 3-4 minutes newer output is predicted.

1.2 Neural Network structure
Neural Network is trained through FFBP method (Feed Forward Back Propagation Method) in which initially weights are assigned on each of the neurons then weights are adjusted iteratively. Natural Neurons receive signals through synapses located on the dendrites or membrane of the neuron. When the signals received are strong enough (surpass a certain threshold), the neuron is activated and emits a signal though axon [16]. The idea behind the adjustment of weights of various neurons to obtain minimum mean square error (MSE). The number of iterations logically should be more if lesser and lesser MSE are required

1.3 Artificial Neural Network based Predictive Model
Table 1 shows 25 input- output data of school children in Himachal Pradesh India. Type of school bag and ratio of school bag weight to body weight were considered as input variables while shoulder MSD is output variable. Artificial Neural Network trains these data with the help of back propagation technique. This technique assigns random weight on each neuron, and then network generates their own input-output relation. The Mean squared error is calculated after getting the difference between observed value and predicted value. It is the ratio of square of this difference (between observed value and predicted value) to total number of data. Mean squared error was kept 0.00001 to obtain this value in the model the back propagation method iteratively tried. The several ingredients of neural network model layer, number of epochs are adjusted through trial and error method. The value momentum was tried from 0.5 to 0.7 but found more suitable at 0.60. Learning rate was considered to be 0.25.The number of hidden layers were tried between 2 to 8 but 2 no. of hidden layers are chosen because it gave better result through trial and error method. Number of neurons was tried between 5 to18, but while 9neurons on each hidden layer were assigned, solution was converging very well i.e. convenience in achievement of goal of Minimum MSE. After so many trials numbers of epochs were considered as 44000. In hidden layer tan sigmoid transfer function however linear transfer function (purelin) is assigned at output layer. The mean squared error is set in the order of 0.00001.Figure 1 depicts the architecture of developed model
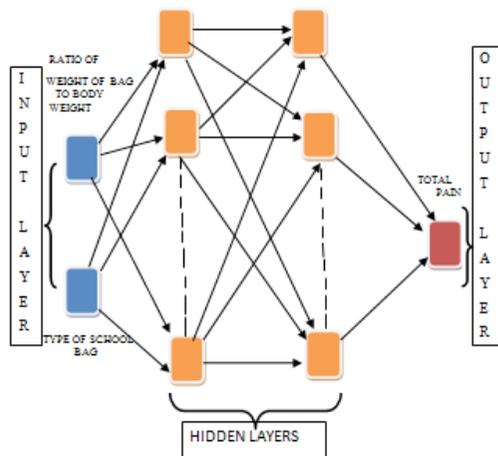
TABLE2. PRIDECTED VALUES THROUGH ANN

BAG TYPE	RATIO OF BAG WEIGHT TO THE RATIO OF BODY WEIGHT	PREDICTED PAIN IN SHOULDER USING ANN
3	25	1.0
1	10	3.0
2	39	4.1
1	15	2.6
3	10	1.3
2	30	4.5
2	20	4.0
3	45	2.3
3	50	3.1
2	33	4.2
1	21	3.1
1	35	5.0
2	35	3.8
3	30	3.6
1	50	4.1

Figure1. ANN Architecture for prediction for pain generated in shoulder pain

TABLE1: DATA INPUT AND OUTPUT OBTAINED THROUGH QUESTIONNAIRE :

TYPE OF SCHOOL BAG	RATIO OF BAG WEIGHT TO THE RATIO OF BODY WEIGHT	PAIN IN SHOULDERS
3	35	2
2	36	3
1	28	3
2	25	2
3	28	2
1	30	4
2	29	3
3	29	2
1	24	1
3	25	2
2	20	4
3	27	1
1	29	4
2	15	2
3	26	1
2	16	4
1	20	3
3	23	2
3	28	2
1	10	3
2	20	4
3	25	1
1	24	4
2	26	3
1	28	4

CONCLUSION:
A study was carried out in the Kangra district of Himachal Pradesh, India to investigate the shoulder MSD In school going children. It was seen that school going children between 10-14 age group were using three types of back pack. When 70 school going children were asked about pain generated in shoulder, 25 students confirmed the shoulder MSD. Average Weight carried by school children was 21% of their body weight. Hence a need was felt to study the sources of pain generation of shoulder. In addition to that it was also realised that a predictive model would give school children and their parents a view about the shoulder MSD. It was found that back pack with wide padded shoulder strap is useful in reducing Shoulder Musculoskeletal disorders.

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