Research Article *ISSN: 2319-507X*
Sudhir Deshmukh, IJPRET, 2013; Volume 1(8): 66-80 *IJPRET*

INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

A PATH FOR HORIZING YOUR INNOVATIVE WORK

EFFECT ON GRIP STRENGTH AND TOUCH SENSATION WHILE WORKING WITH HAND OPERATED POWER TOOLS

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Accepted Date:

27/02/2013

Publish Date:

01/04/2013

Keywords

Segmental vibration,

Grip strength,

Touch sensation,

Hand held power tools

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Abstract

In many industrial and agriculture working environment operators has to use power operated hand tools these tools often induced vibration which is called as segmental vibration. Segmental vibration causes various disorders which are called as hand arm vibration syndrome affecting the productivity and personal life of workers. Hand grip is a major phenomenon in the study of hand operated tools. In this study the workers were selected from three different occupations. They were asked to perform occupational task without any interference. Grip strength of each subject was measured before the performance and after the performance, to understand the influence of vibratory tools on grip strength. Along with grip strength the touch sensation of each operator was studied. It is observed that the heavy power tools i. e. concrete breaker and rock drill influences grip strength and touch sensation as compare to light tool like hand grinder. It is also observed that operators having larger value of grip strength influenced fewer changes over grip strength and touch sensation.

I. INTRODUCTION

The contact force is linearly dependent upon the grip and pushes forces and handle diameter. The hand–handle contact force for a given handle size could be derived from a linear combination of the grip and push forces, where the contribution due to grip force is considerably larger. The variations in push force tend to cause a constant shift in the contact force over the entire range of grip forces. [1] The experiment demonstrated that the effect of vibration on muscles of the arm and shoulder system. Vibration was transmitted from a handle to the arm and shoulder in upright standing posture and affected the muscles. The different parameters of vibrations in the human body, and work-related factors such as gripping force and posture also have influence on this [2]

The ratio between pinch and grip forces for industrial workers were higher (1: 6) compared to those of students. The absolute magnitude of maximal voluntary contraction produced by industrial workers was similar to those of student sample reported in earlier study. [3]

Regression analysis was used to develop prediction models for the rest period, duty cycle, and rest-to-work ratio as a function of anthropometric dimensions of the hand and wrist, age, force, wrist angle, exertion period, maximum voluntary contraction (MVC), maximum deviation angle (MDA), and the percentage of MVC. The results of the regression analysis indicated that anthropometric dimensions and age were not significant factors. [4]

Force recall technique shows some promise as an alternative to expensive and fragile force-sensing instrumentation, and it should be further studied as a method for characterizing grip and push forces in field and laboratory settings. Subjects tended to overestimate grip and push forces over the entire range of operationally-relevant hand–handle coupling forces and vibration exposure conditions, especially at the lower force targets. [5]

While hand forces can be effectively and accurately measured with dynamometers and handgrip and pinch strength meters, it remains a formidable task to quantify hand forces applied to vibratory tools in the workplace. Several methodologies have been utilized for measuring hand coupling forces on tool handles. [5]

Power driven hand tools are used in variety of industries (e.g. agricultural, construction, logging and manufacturing). These tools are also used in dental and medical work. During the operation with power tools the workers directly come in contact with it. Due to this physical contact, the vibration induced by these tools passed in the body of worker through palm and finger this type of vibration influencing part body of worker is called as segmental vibration [6], [7], [8]

The most important sources of hand arm vibration (HAV) are pneumatic tools (air compressed and electrical), for example, grinders, sanders, drills, fettling tools, impact wrenches, jack hammers, and riveting guns. Users of chainsaws, brush saws, hedge cutters, and grass trimmers are also at risk [9].

Hand-arm vibration syndrome is a condition associated with the use of hand-held vibrating tools. Vibration can cause changes in tendons, muscles, bones and joints as well as affecting nerves. Collectively, these effects are known as Hand-Arm Vibration Syndrome (HAVS) [10]. HAVS is also called as Raynaud's phenomenon of occupational origin, vibration-induced white finger (VWF), dead finger, and traumatic vasospastic disease and vibration syndrome [11]. HAVS is a complex syndrome caused by the constriction of blood vessels in the fingers, and involves circulatory, sensory, motor and musculoskeletal disturbances [11].

Some of the presenting complaints are attacks of whitening (blanching) of one or more fingers when exposed to cold often associated with pain, tingling and numbness in the affected finger, loss of sensation, tactile discrimination & manipulative dexterity, pain and stiffness in the hands and wrists, loss of grip strength, and bone cysts in the fingers & wrists [10]. The development of HAVS is gradual and increases in severity with time, often taking a few months to several years for the symptoms of HAVS to be noticeable depending on the vibration exposure dose [10]. Histological changes in blood vessel walls and nervous tissues are irreversible, resulting in the long-term circulatory and nervous dysfunction [12].

At low frequency the perception is transmitted to the arm therefore the perception is high. The perception greatly decreases with frequency with the reduction of vibration transmissibility throughout the hand arm system [13]. When the organs are subjected to vibration at their specific resonance frequencies, the energy transfer from the source to the exposed part will be maximum and adverse effects will be more [14].

The existence of sensory and vascular components in HAVS lead to the adoption of the Stockholm grading based on the subjective history supported by the results of clinical tests [9]. Muscle weakness, particularly affecting the long finger flexors and affecting grip strength, may occur in association with long-term vibration exposure from hand-held tools [15].

Progression through the stages is most likely with all components if there is no reduction in vibration exposure. However, there is a good deal of physiological evidence that while the dose response relationships are fairly linear, the actual path physiological response has something of an all or none quality [9].

The international standard for assessing exposure to hand- transmitted vibration, ISO 5349-1 (2001) indicates that hand coupling forces influence the vibration energy transmitted to the hand [16].

II. MATERIALS AND METHODS

A. Subjects

Twenty one subjects seven each for three occupations were selected (Rock drilling, Concrete breaking and Hand grinding) for the purpose of study. The purpose was to assess the effect of segmental vibration on grip strength and touch sensation of subjects. The anthropometric data of subject is shown in table I. The subjects are labeled as A1 to A21.

A. Type of hand held power tools:

The tools those were selected for study include

1) Rock drill (Dry type) (Tool-1)
2) Concrete breaker (Tool-2)
3) Hand grinder (Tool-3)

The specifications of these tools are shown in table II, III, IV respectively.

C. Equipment and instruments

Hand grip of subjects is measured by using hand grip dynamometer. The dynamometer used for this purpose is known as Lafayette or Stoelting dynamometer (Figure2). The subject to be tested holds the dynamometer in the hand to be tested, with the arm at right angles and the elbow by the side of the body, The base rest on the heel of palm, while the handle rest on middle of four fingers. The hand grip of each hand is measured and added to get aggregate hand grip it is measured in Kg. Similarly hand grip was measured after the test of fifteen minutes.

D. Experimentation Procedure

Run of fifteen minute for each tool for different seven subjects was carried out. Subjects were asked to perform as they perform their regular work as an occupation. Operator of hand grinder perform the task grinding of steel frame, operator of concrete breaker perform the task of road breaking and operator of rock driller perform the task of making a drill in rock. After the given task grip strength of each hand was measured and to know aggregate grip strengths of each individual. To measure touch sensation scale of four points was developed based on the sensation at nail it was categorized as high, medium, low and no effect touch sensation.

III RESULT & DISCUSSION

Table VI, VII, & VIII shows the changes in grip strength and effect on touch sensation for tool 1, tool 2 and tool 3 respectively. It can be observed that changes in grip strength are more for tool 2 and tool 3. The task on hand grinder is light as compare concrete breaker and rock driller. The graph in figure 2,3 and 4 shows shift in grip strength of subjects after performing on their respective tools. Also graph in figure 5,6 and 7 shows touch sensation is more while working with high vibrating tools like concrete breaker and rock drill. It can also be observed from above graph that subjects with higher grips strength are lesser affective to change in touch sensation and grip strength.

The material on which the rock drills work was hardest amongst the material on which the other two tools worked. The impact rate and stroke of rock drill was more than concrete breaker. Among the three tools, the weight and speed (rpm) of hand grinder was least. The performance on the hand grinder was under roof. This is another reason of less effect on grip strength and touch sensation.

IV. CONCLUSION

The conclusions drawn are as follows-

The rock drill shows maximum change in grip strength flowed by concrete breaker and hand grinder.

Subjects with more grip strength were lesser affected in grip strength and touch sensation.

There is a relationship between grip strengths and tocuch sensation subjects of more grip strength have lesser affect on touch sensation.

Study clearly indicates how vibration inducing hand held power tools influences grip strength touch sensation leading towards hand arm vibration syndromes (HAVS).

Table I. Anthropometric Data of Subjects

Tools	Subjects No.	Age (Yrs)	Weight (kg)	Height (cm)	Functional overhead reach (cm)	Knuckle height (cm)	Elbow height (cm)	Grip Strength (Kg) Left	Grip Strength (Kg) Right	Aggregate grip strength
1	A1	29	47	162	205	56	101	40	38	**78**
	A2	25	50	160	202	54	100	48	48	**96**
	A3	23	75	170	214	68	106	75	70	**145**
	A4	35	60	174	218	72	108	55	56	**111**
	A5	41	58	165	208	58	103	56	58	**114**
	A6	45	59	169	212	61	106	60	62	**122**
	A7	34	66	171	216	69	107	61	68	**121**
	Mean	33	59	167	211	63	104	56	59	**115**
	SD	7	9	5	6	7	3	11	11	**11**
2	A8	30	50	160	211	68	104	48	45	**93**
	A9	22	55	168	215	70	104	60	55	**115**
	A10	44	72	178	224	74	114	67	68	**135**
	A11	44	57	166	213	67	102	62	69	**131**
	A12	35	59	163	214	70	104	50	54	**104**
	A13	37	64	167	214	70	103	65	68	**133**
	A14	39	48	160	210	67	100	48	52	**100**
	Mean	36	58	166	214	69	104	57	59	**116**
	SD	7	8	6	5	2	5	8	10	**9**
3	A15	30	50	163	206	58	101	49	47	**96**

A16	29	68	164	214	59	104	58	62	**120**
A17	35	72	176	216	70	110	71	76	**147**
A18	34	65	162	212	56	101	58	64	**122**
A19	38	67	165	214	61	107	66	60	**126**
A20	49	48	160	202	55	99	39	40	**79**
A21	36	70	170	211	65	105	63	69	**132**
Mean	36	63	166	211	61	104	56	56	**112**
SD	**6**	**10**	**5**	**5**	**5**	**4**	**10**	**11**	**11**

Table II. Specifications of Tool 1 (Rock Drill)

Model	HAVA RH-658-5L
eight	25 kg
Air requirement at 6 bar	3.4 m3/min
Piston diameter	65 mm
Piston stroke	60 mm
Impact rate	2000 blows/min
Drilling rate	425 mm/min
Hose connection (Air)	19 mm
Rotation speed	215 rpm

Table III. Specifications of Tool 2 (Concrete breaker)

Model	Drillman DM221
Weight	35 kg
Length	740 mm
Shank size	32*160 mm
Stroke	165 mm
Frequency	1200 blows/min
Piston diameter	57.15 mm
Air consumption	2.5 m^3/min
Hose connection for air	ϕ 19mm

Table IV. Specifications of Tool 3 (Hand Grinder)

Model	KPT 57-91
Weight	6.9 kg
Rated voltage	110-240
Frequency	50-60 Hz
Speed	8200 rpm
Input power	2.0 kw
Grinding wheel diameter	180mm

Table V. Observations during Runs of Tool 1

Subjects	Aggregate grip strength before test	Aggregate grip strength after test	Environmental Variables		Touch Sensation Nail test			
			Temp. ^{0}C	Humidity %	High	Moderate	Low	**No. effect**
A1	78	76	33				y	
A2	96	94		38		y		
A3	145	145						**y**
A4	111	108				y		
A5	114	112					y	
A6	122	120					y	
A7	**121**	**119**						**y**

Table VI. Observations during the Runs of Tool 2

Subjects	Aggregate grip strength	Aggregate grip strength after test	Environmental Variables		Touch Sensation Nail test			
			Temp. ^{0}C	Humidity %	High	Moderate	Low	**No. effect**
A8	135	130	37	39				**y**
A9	115	111				y		
A10	93	80			Y			
A11	135	129					y	

A12	115	99				y		
A13	93	80			Y			
A14	**135**	**129**				**y**		

Table VII. Observations during the Runs of Tool 3

Subjects	**Aggregate grip strength**	**Aggregate grip strength after test**	**Environmental Variables**		**Touch Sensation Nail test**			
			Temp. ^0C	Humidity %	High	Moderate	Low	**No. effect**
A15	96	80	38	40	y			
A16	120	110			y			
A17	147	142				y		
A18	122	115				y		
A19	126	109				y		
A20	79	68			y			
A21	**132**	**122**					**y**	

ISSN: 2319-507X
IJPRET

Figure 1: Measurement of grip strength

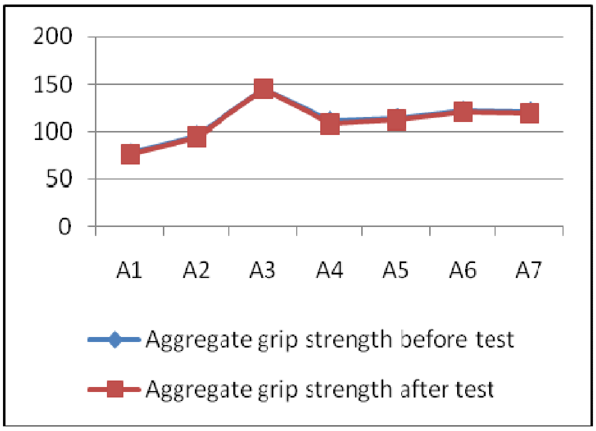

Figure2: Graph Showing Change in Grip Strength for after test for tool 1

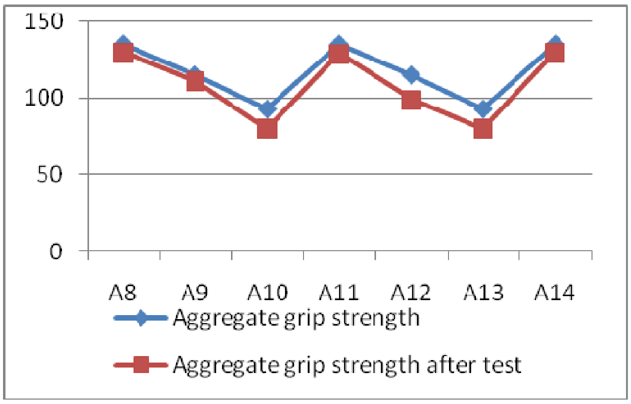

Figure3: Graph Showing Change in Grip Strength for after test for tool 2

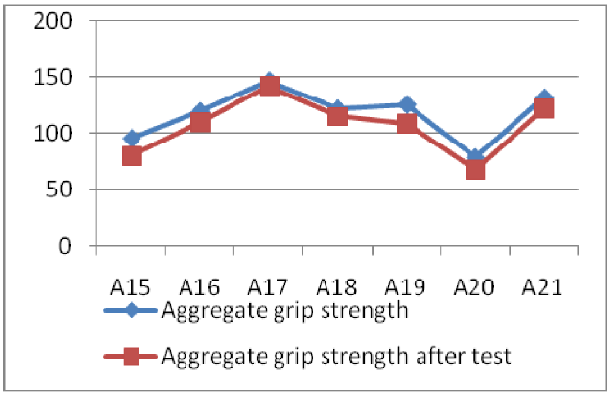

Figure4: Graph Showing Change in Grip Strength for after test for tool 3

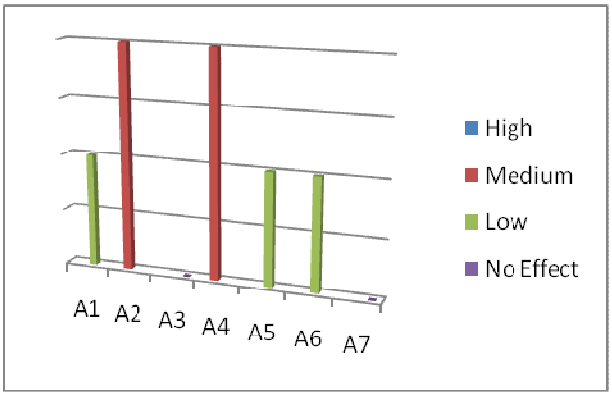

Figure5: Graph showing change in touch sensation of subjects for tool 1

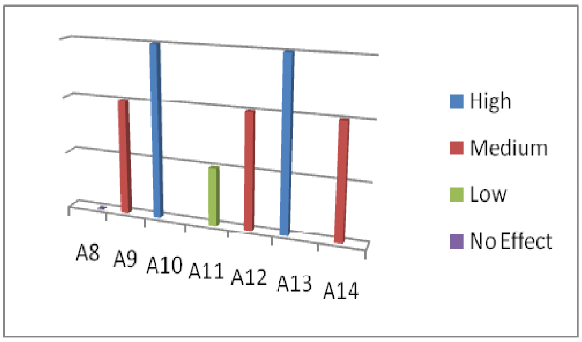

Figure6: Graph showing change in touch sensation of subjects for tool 2

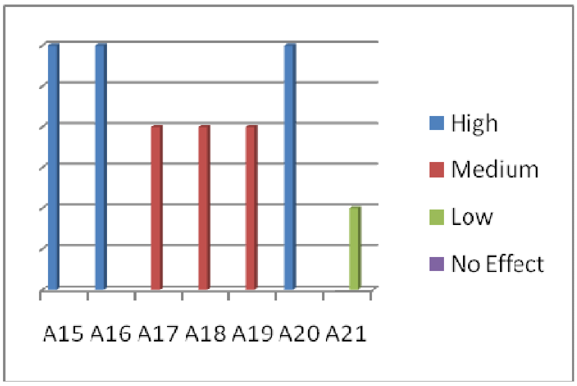

Figure7: Graph showing change in touch sensation of subjects for tool 3

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