ANALYSIS OF CORRELATION BETWEEN THE VARIABLES OF TEMPERATURE, STRENGTH AND CYCLES PER MINUTE TO PERFORM HORIZONTAL REPETITIVE MOVEMENTS OF THE WRIST

Camargo Wilson Claudia[1, 2], Rivera Valerio Abril A.[1], Rubio Martinez Jesus R.[1], de la Vega Bustillos Enrique J.[3], López Bonilla Oscar R.[2], Olguín Tiznado Jesús E.[1, 2], Báez López Yolanda A.[1, 2]

[1] Department of Industrial Engineering - Engineering Faculty Ensenada.
Autonomous University of Baja California.
Km. 103 Highway Tijuana-Ensenada S/N
Ensenada, Baja California. Zip code 22760
ccamargo@uabc.edu.mx, abrilriva@hotmail.com, rodolforubio@yahoo.com

[2] Division of Posgrade and Research MyDCI- Engineering Faculty Ensenada.
Autonomous University of Baja California.
Km. 103 Highway Tijuana-Ensenada S/N
Ensenada, Baja California. 22760
olopez@uabc.edu.mx, jeol79@uabc.edu.mx, yolanda@uabc.edu.mx

[3] Division of Postgraduate Studies and Research
Technological Institute of Hermosillo
Technological Avenue S/N
Hermosillo, Sonora. 83170
e_delavega_mx@yahoo.com

RESUMEN. La necesidad de proteger a los trabajadores contra las causas que provocan tanto enfermedades profesionales como accidentes de trabajo es una cuestión indudable. De ahí el interés de analizar el comportamiento que tienen las variables de temperatura en el área de la muñeca, la fuerza y los ciclos por minuto ello al llevar a cabo movimientos repetitivos horizontales de la muñeca, los cuales son comúnmente encontrados en los lugares de trabajo. *Objetivos:* Correlacionar las variables de temperatura, fuerza y cantidad de movimientos por minuto cuando se trabaja con el movimiento repetitivo horizontal en el área de la muñeca. *Delimitación del problema:* Se simuló la jornada laboral de ocho horas con dos operadores (hombre y mujer) ejerciendo los movimientos horizontales, en las instalaciones de la Facultad de Ingeniería Ensenada de la Universidad Autónoma de Baja California. Metodología: Se simuló la jornada laboral con dos operadores ejerciendo los movimientos horizontales, para ello se realizó el registro de la temperatura en el área de la muñeca derecha (termógrafo sensorial Sköll), la fuerza del individuo (dinamómetro de torsión de muñeca Baseline) y los ciclos por minuto, los tres

registros mencionados anteriormente se realizaban cada diez minutos. Resultados: Los resultados obtenidos fueron los siguientes: *en el operador 1*, se encontró correlación en los ciclos por minuto contra temperatura y contra fuerza; además el máximo en: la temperatura fue 35.93°C, la fuerza 82 kg y los ciclos por minuto fue de 138 movimientos y el mínimo en: la temperatura fue 28.11°C, la fuerza 36 kg y los ciclos por minuto fue de 93 movimientos; *en el operador 2* la correlación que se manifestó fue la de ciclos por minuto contra temperatura; además el máximo en: la temperatura fue 34.87°C, la fuerza 63 kg y los ciclos por minuto fue de 140 movimientos; y el mínimo en: la temperatura fue 29.38°C, la fuerza 32 kg y los ciclos por minuto fue de 100 movimientos. Conclusiones: En base a este estudio se concluye que: existe correlación entre *temperatura contra los ciclos por minuto* y entre la *fuerza contra ciclos por minuto*; asimismo que no existe correlación entre *temperatura y fuerza*.

Palabras clave: Temperatura, Fuerza, Ciclos por minuto.

ABSTRACT. The need to protect workers against the causes of occupational diseases and accidents is a no doubt question. Hence the interest to analyze the behavior with variables in temperature in the area of the wrist, strength and cycles per minute, that to perform horizontal repetitive movements of the wrist, which are commonly found in workplaces. *Objective:* The objective was to correlate the variables of temperature, strength and number of movements per minute when working with horizontal repetitive movement of the right hand wrist area. *Delimitation of the problem*: It was simulated a working day of 8 hours with 2 operators (man and women) exerting horizontal movements, on the installations of the Faculty of Engineering Ensenada of the Autonomous University of Baja California. *Methodology:* It was simulated a working day with two operators exerting horizontal movements, and for this making the temperature recorder in the area of the right hand wrist (sensorial thermograph Sköll), the strength of the operator (dynamometer wrist-twisting Baseline) and cycles per minute, the three mentioned records were made every ten minutes. *Results:* The obtained results were: in *the operator 1 ,*there was a correlation in cycles per minute against temperature and against strength, besides the maximum in: temperature was 35.93°C, strength was 82 kg and cycles per minute was 138 movements and the minimum in: temperature was 28.11°C, strength was 36 kg and cycles per minute was 93 movements; in *the operator 2:* there was a correlation in cycles per minute, besides the maximum in: temperature

was 34.87°C, strength was 63 kg and cycles per minute was 140 movements and the minimum in: temperature was 29.38°C, strength was 32 kg and cycles per minute was 100 movements. *Conclusion:* On based on this study the conclusion was: correlation exists between *temperature against cycles per minute* and *strength against cycles per minute*; and there is no correlation between *temperature and strength*.

Keywords: Temperature, Strength, Cycles per minute.

1. INTRODUCTION

The need to protect workers against the causes of occupational diseases and accidents is a question no doubt. All sources of work should carry out activities aimed at the prevention of occupational hazards, with consequent advantages in production and productivity, achieving greater social welfare, which is reflected in the economy of the company. The ergonomic approach is to design products and work to adapt them to the people and not vice versa. The logic that uses the ergonomics is based on the principle that people are more important than the objects or production processes; and therefore, cases where it arises any conflict of interest between people and things, should prevail people (Tortosa et al., 1999).

Ergonomic hazards have been an issue to consider, for injuries caused to workers in work areas. For industry it is always important the health of the workers, because by avoiding the DTA's in it reduces their costs for disabilities, absenteeism and more importantly for investors.

Musculoskeletal injuries are disorders characterized by an abnormal condition of muscle, tendons, nerves, vessels, joints, bones or ligaments, which results in impairment of motor or sensory function caused by exposure to risk factors: repetition, strength, inappropriate postures, contact stress and vibration (Sinclair, 2001). For example, some of the injuries and illnesses common in the wrist area causing repetitive or poorly designed work are:

- Tenosynovitis: is an inflammation of the synovial capsule, this is the sheath that covers tendons. Tenosynovitis can occur in any tendon with a synovial sheath. However, most often

occurs in the hand, wrist or foot. Most cases of tenosynovitis are caused by injury, infection, twisting, repetitive movement as: operate a computer, working on an assembly line, the cashier of a bank, sewing, playing musical instruments like violin or guitar (http://nlmnih.gov/medlineplus/ency/article/001242.htm)

- Ganglia: it is a cyst in a joint or tendon sheath, usually in the back of the hand or wrist. (http://www.itcilo.it/actrav/osh_es/módulos/ergo/ergoa.htm)
- Epicondylitis: is an inflammation of muscle attachments at the epicondyle of the elbow, the pain may appear in the muscles of the forearm and wrist. The causes that provoke are: Task force loading and repeatability, often in stressful jobs such as carpentry, plastering or bricklaying. (http://www.tiroriojano.com/lesiones/EPICONDILITIS.htm)
- Crimping finger: is an inflammation of the tendons and / or tendon sheaths of the fingers. By use of air guns or staplers (International Labor Organization, 2004).
- Carpal Tunnel Syndrome: presented by the type of horizontal repetitive movement and the disease that affects people. It is a Repetitive Strain Injury better documented, currently classified as compensable occupational disease in many countries. This syndrome affects the median nerve (one of the principal nerve in the wrist). Extreme cases can lead to permanent disability due to the absolute inability to flex the wrist to perform tasks as simple as operating a computer or holding an object in the hand. Affects workers who process meat or poultry, supermarket cashiers who use electronic scanners, the use of vibrating hand tools.

In the United States with this syndrome each worker loses more than 30 working days, a figure higher than absenteeism from amputations and fractures. It has been estimated annual cost of these lesions in more than 100 million dollars (International Labor Organization, 2004).

These injuries and illnesses caused by workplace tools and poorly designed or inappropriate usually develop slowly over months or years. However, a worker wills usually signs and symptoms for a long time to indicate that something is wrong. For example, the worker will be uncomfortable while doing their work or feel pain in muscles or joints once home after work. You can also have small muscle twitches for some time. It is important to investigate the problems of this kind, because what may begin with a mere inconvenience in some cases can end in injury or disease that severely incapacitated workers.

Employees often have no choice and are forced to adapt to poorly designed work conditions that can seriously injure the hands, wrists, joints, back or other body parts. In particular, injuries can occur due to:

- The repeated use over time vibrating tools and equipment,
- Tools and tasks that require turning the hand movements of the joints, for example the work performed by many mechanics;
- The application of strength in a forced position;
- The application of excessive pressure on parts of the hand, back, wrists or joints.

All of them will generate absenteeism and each day of absenteeism for health reasons is a cost. A day lost disability implies a direct cost and indirect. (Beevis, 2003; Derango, 2002; Hendrick, 2003).

This study aims to correlate the variables of temperature, strength and cycles per minute all this by repetitive horizontal movements, applied to a man and a woman which are commonly found in workplaces.

The benefit of this study is that it will have social impact, economic and scientific:

- The social impact, achieving avoid injury to the worker and it will be productive in your work area and have better social welfare.
- The economic impact, because if the DTA's are avoided in work areas will reduce annual costs by the company.
- The scientific impact, because it is a sensorial thermography technique actually not used.

1.1 Related Articles

Gold et. al., (2004) in the article entitled "Infrared Thermography for Examination of skin temperature in the dorsal hand office workers", identified differences between skin temperatures between 3 groups of office workers through dynamic thermography, we have the experiment when writing computer keyboard for 9 minutes at a time. It highlights the temperature of testing room as an important factor.

Ming, et. al., (2005) in the article entitled "Sympathetic pathology evidence by hand thermal anomalies in carpal tunnel syndrome", the aim of this study was to classify the pathology compassionate in carpal tunnel syndrome and the use of infrared thermography. Exercise was conducted in which subjects were kept at room temperature between 22 and 25˚C for 15 minutes at room temperature are highlighted in the testing room as an important factor.

Zontak, et. al., (1998) in the article entitled "Dynamic Thermography: Analysis of hand temperature During exercise", the aim of this study was to characterize the effect of exercise and responses in the skin temperatures due to controlled levels of exercise temperature conditions, making a ergonomics bicycle.

Tchou, et. al., (1991) in the article entitled "Thermographic observations in unilateral carpal tunnel syndrome: Report of 61 cases", its purpose was to characterize the effect of exercise and responses in the skin temperatures, as an exercise the balance of hands for 15.

Kyeong-Seop, et. al., (2006) in the article entitled "Infrared Thermography in Human Hand" estimated temperature conditions that could cause mental stress. Dipping both hands in a container of water at a temperature of 3˚C.

Ferreira, et. al., (2007) in the article titled "Exercise-Associated Thermographic Changes in Young and Elderly Subjects", determined thermographic temperature changes associated in elderly and young people, doing knee bends with a weight of 1 kilogram added to the same for 3 minutes.

2. OBJECTIVE

This study presents the following objectives:

- To correlate the variables of temperature, strength and number of movements per minute when working with horizontal repetitive movement of the right hand wrist area.
- To show the application of sensorial thermography.
- To develop preliminary test emulating a manufacturing industry repetitive operation.

3. METHODOLOGY

This study was performed at the facilities of the Autonomous University of Baja California from 5 to September 11, 2009. The study involved a man and a woman using the dominant hand (both being right-handed), which are healthy people with age 24 being the average age of the economically active population, students in undergraduate and in unskilled industrial manual material handling.

To achieve the objective of this study, was simulated eight-hour workday to exercise horizontal repetitive movements as shown in Figure 1.

Figure 1: Horizontal repetitive movement

The record was made to register the temperature in the area of the wrist with a sensorial thermograph Sköll for each operator placed at the height of the wrist in the right hand figure 2, the strength of the individual with a dynamometer wrist-twisting Baseline (Figure 3) and cycles per minute.

Figure 2: Sensorial Thermograph Sköll

Figure 3: Dynamometer wrist-twisting Baseline

It is noteworthy that the three records mentioned above were made with a timer (Figure 4) every ten minutes.

Figure 4: Timer

4. RESULTS

The table 1 and 2 are shown in the data from the experiment with horizontal repetitive movement of the operator 1 and the operator 2 within 7 days. In the second line of the both tables: 1 means cycles per minute, 2 means strength and 3 means temperature.

Table 1. Data concentrate of the operator 1 in the 7 days.

	Day 1			Day 2			Day 3			Day 4			Day 5			Day 6			Day 7		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1	125	65	33.14	125	59	34.21	93	56	31.98	119	60	31.97	122	65	32.48	130	62	33.26	130	61	33.34
2	132	63	33.35	135	58	33.61	111	57	32.41	122	68	32.50	122	67	32.86	131	60	33.22	128	62	33.58
3	130	62	33.27	128	62	33.86	120	55	32.44	127	71	32.41	125	68	32.78	131	58	33.10	129	63	33.44
4	137	60	33.39	135	61	34.52	124	54	32.67	120	70	32.79	130	66	33.07	133	59	32.85	129	65	33.61
5	131	57	33.51	131	55	34.30	123	48	32.83	124	71	32.68	130	70	32.92	131	60	32.51	130	60	33.39
6	134	52	33.90	134	52	34.01	125	47	32.14	118	72	32.51	135	74	32.45	132	63	32.20	131	58	33.20
7	134	51	34.36	134	51	34.09	120	47	32.11	124	70	32.07	135	72	33.17	133	62	33.04	132	60	33.35
8	129	52	34.28	136	52	34.10	120	46	31.72	125	69	31.87	132	70	33.37	134	59	32.44	128	63	33.18
9	132	54	34.40	132	54	34.10	121	48	31.79	120	67	32.18	132	71	32.54	125	55	32.71	132	71	33.86
10	133	53	33.77	133	52	34.75	118	47	31.91	128	66	31.85	130	72	32.78	132	56	32.99	134	69	34.18
11	134	52	33.45	134	52	34.46	120	50	32.36	132	68	31.86	130	74	32.70	132	59	32.53	134	71	34.42
12	135	53	33.15	135	53	33.95	118	52	32.16	135	69	31.59	132	71	32.59	133	63	32.67	131	77	34.47
13	135	52	32.61	135	52	34.53	124	51	32.43	135	65	31.31	131	72	32.45	134	61	33.21	134	75	34.09
14	133	50	32.94	133	50	34.79	130	49	32.72	134	67	32.38	130	74	32.34	132	60	33.14	134	79	33.32
15	125	48	33.07	130	48	34.63	120	50	32.49	138	69	33.42	130	73	32.24	135	63	33.15	136	82	33.15
16	138	50	32.59	136	47	34.44	118	51	32.72	137	66	32.95	133	75	32.57	130	62	33.66	135	80	32.97
17	135	53	32.51	135	50	34.46	115	54	33.18	120	63	33.35	130	72	32.70	137	65	33.90	134	79	33.57
18	135	55	32.51	135	55	34.37	118	56	33.52	130	60	33.62	135	73	32.65	134	66	33.29	135	77	33.01
19	136	56	32.14	136	54	34.24	120	53	33.25	130	64	33.57	135	70	32.39	137	65	32.74	135	76	32.58
20	138	57	32.61	138	55	34.71	128	52	33.64	133	66	33.81	134	69	31.61	132	66	31.79	136	74	32.85
21	134	56	32.09	134	56	34.71	123	55	33.43	123	67	34.25	136	65	32.56	137	68	32.11	130	72	32.99
22	133	55	32.44	133	55	35.36	134	53	32.91	134	69	32.70	120	64	32.22	136	66	32.06	130	70	33.57
23	135	56	32.30	135	56	35.48	127	46	33.08	120	70	33.41	128	67	32.37	132	60	31.86	131	67	34.15
24	136	57	32.17	136	57	33.73	118	40	33.23	133	73	33.44	130	65	33.31	135	55	32.13	135	65	33.43
25	136	54	32.38	136	54	33.97	134	44	33.60	137	71	33.84	128	68	33.90	137	54	32.41	134	66	33.51
26	134	56	33.01	134	56	34.57	128	47	33.67	138	65	33.17	130	70	32.80	138	55	32.92	136	68	33.39
27	136	58	32.08	136	58	34.81	128	49	33.63	130	60	33.54	132	71	32.90	132	57	32.78	135	65	33.28
28	137	60	32.54	137	57	34.72	122	48	33.60	125	62	33.74	122	70	33.32	132	58	32.83	135	63	33.19
29	138	63	33.34	138	62	34.82	130	45	33.08	122	64	33.77	133	67	33.09	131	62	33.34	136	60	33.36
30	137	65	34.23	137	65	34.65	126	38	34.19	125	65	33.71	130	68	32.81	130	66	33.70	136	62	34.03
31	135	65	33.98	135	63	35.12	118	40	34.04	128	66	33.38	128	67	33.58	134	64	34.29	136	68	33.56
32	136	66	34.23	136	65	35.15	118	42	32.75	132	68	32.89	135	65	33.30	131	62	34.40	136	70	33.79
33	135	67	34.04	135	67	34.32	128	43	33.47	120	69	32.90	136	66	34.31	133	60	34.34	134	72	33.89
34	138	65	34.42	138	66	34.39	127	44	32.76	138	67	34.41	134	65	34.29	127	59	34.32	136	70	33.63
35	137	66	34.07	137	67	34.58	120	47	32.88	128	65	34.70	135	64	33.64	130	55	34.18	135	67	33.66
36	138	68	33.85	138	68	34.64	120	54	32.91	125	64	34.13	135	63	32.52	133	54	33.67	136	60	33.52
37	138	67	34.34	138	66	34.44	118	50	32.94	135	62	34.18	135	61	33.01	136	56	33.80	135	64	34.69
38	137	64	32.17	136	65	34.67	115	48	33.15	133	60	32.66	135	60	32.80	132	59	33.77	137	62	35.94
39	137	62	32.57	137	62	34.75	128	36	33.47	132	58	28.11	134	62	34.24	136	63	34.62	135	61	33.13

Table 2. Data Concentrate of the operator 2 in the 7 days.

	Day 1			Day 2			Day 3			Day 4			Day 5			Day 6			Day 7		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1	131	61	32.85	136	50	33.35	110	58	34.17	112	50	32.44	136	53	32.79	121	50	33.03	134	52	33.34
2	118	61	33.28	133	51	33.71	113	57	33.87	112	46	32.39	138	55	32.91	130	52	32.85	130	55	33.58
3	127	60	33.46	138	52	33.41	116	56	33.56	125	44	31.91	132	56	32.80	133	53	33.38	127	56	33.44
4	110	59	33.90	128	51	33.45	118	57	33.92	124	43	31.63	130	54	32.59	130	52	33.01	127	57	33.61
5	121	58	33.85	120	48	33.15	116	57	34.09	122	51	30.50	129	56	31.69	128	51	32.62	123	49	33.39
6	119	58	33.67	127	47	33.27	120	58	33.91	118	53	30.63	133	58	32.21	124	52	33.18	126	48	33.20
7	129	57	33.73	127	46	33.52	101	58	33.91	127	52	30.95	128	57	31.96	125	51	32.45	128	47	33.35
8	125	58	33.74	130	49	33.58	128	59	33.54	129	54	30.64	128	56	31.94	130	50	32.01	124	48	33.18
9	127	59	33.76	133	50	33.35	111	59	33.32	128	55	30.97	126	58	31.73	129	52	32.31	127	49	33.86
10	126	60	33.69	132	51	33.71	115	58	33.82	109	54	29.38	136	56	31.69	125	53	32.24	128	47	34.18
11	132	60	33.79	125	51	33.41	119	57	33.78	126	55	32.09	134	55	30.92	129	54	32.82	127	49	34.42
12	123	61	33.60	136	52	33.45	123	56	33.70	130	56	32.29	135	53	31.04	129	55	32.66	130	50	34.47
13	128	62	33.50	134	50	33.15	125	56	34.25	118	55	32.94	137	54	30.43	128	54	32.65	134	51	34.09
14	127	63	33.41	125	48	33.27	115	56	34.03	130	56	32.59	131	55	30.48	125	51	32.63	128	50	33.32
15	123	62	33.46	140	46	33.52	109	56	34.12	123	55	32.37	133	57	31.98	130	50	33.66	128	52	33.15
16	126	60	33.69	124	57	33.58	126	54	34.00	126	54	32.43	136	56	32.29	128	49	33.66	127	51	32.97
17	124	57	33.35	100	50	33.74	117	52	34.12	114	52	33.40	124	55	32.87	129	51	32.99	128	53	33.57
18	128	55	33.04	113	52	33.88	120	50	34.56	134	51	33.33	125	54	33.46	128	50	33.28	124	55	33.01
19	129	54	33.11	117	51	33.76	125	49	34.62	126	50	33.15	137	53	33.17	127	52	33.23	126	54	32.58
20	129	50	33.12	122	52	33.58	119	47	33.61	133	51	32.40	136	55	33.53	129	50	33.01	127	52	32.85
21	123	48	33.32	118	53	33.55	122	46	33.80	130	54	32.04	125	56	33.92	132	51	33.28	126	53	32.99
22	128	46	33.51	126	51	34.84	129	46	33.59	127	53	32.71	120	54	33.70	129	50	33.25	127	53	33.57
23	126	42	33.62	128	50	33.73	124	46	34.35	127	56	32.67	124	53	33.10	123	48	33.07	130	55	34.15
24	120	39	33.62	120	49	33.78	129	46	33.92	120	58	32.41	124	52	33.30	129	46	33.61	132	57	33.43
25	122	38	33.62	118	48	34.06	128	49	33.52	129	57	32.46	125	51	33.21	135	45	33.43	133	56	33.51
26	131	56	33.59	122	47	33.73	131	51	34.22	120	54	32.08	127	54	33.38	134	46	32.99	132	55	33.39
27	125	58	33.31	114	45	33.73	121	53	34.88	131	53	31.54	130	56	33.09	130	47	33.48	132	54	33.28
28	122	56	33.50	122	44	33.72	123	52	34.62	135	52	31.04	125	55	32.51	134	48	33.59	132	53	33.19
29	128	50	33.72	121	47	33.36	118	51	34.55	115	48	30.86	132	48	32.63	134	52	33.84	130	56	33.36
30	126	47	33.74	116	49	33.50	127	50	34.55	128	47	30.75	131	47	33.62	132	57	33.37	134	58	34.03
31	133	46	33.37	121	48	32.94	124	50	34.75	125	46	30.83	126	58	34.27	130	56	33.76	126	57	33.56
32	119	40	33.95	122	47	32.75	128	51	34.81	132	46	30.62	121	50	34.18	134	48	33.39	128	59	33.79
33	127	38	33.91	122	48	33.23	125	52	34.28	123	47	30.57	130	55	33.60	129	45	33.28	130	62	33.89
34	129	36	33.78	120	46	32.95	118	52	34.38	125	48	30.62	132	53	32.85	131	44	33.11	129	60	33.63
35	110	37	33.71	121	48	32.77	128	53	34.24	112	53	30.56	131	52	32.71	131	43	33.09	128	57	33.66
36	129	38	33.50	129	49	33.69	105	54	34.21	120	55	30.52	127	51	32.85	132	45	32.95	126	56	33.52
37	116	37	33.47	125	50	33.78	123	53	34.34	129	54	30.48	126	50	33.35	131	44	32.99	124	55	34.69
38	131	35	33.57	126	49	33.28	110	52	34.21	119	51	30.56	120	52	32.77	134	45	33.57	126	53	35.94
39	122	32	33.80	120	48	33.84	116	51	34.34	124	49	30.56	125	54	33.75	129	43	33.54	124	49	33.13

4.1 Analysis of correlation.

In the figure 1 is shown the correlation between temperature and strength in the 7 days, where r is 0.041. As r is 0.041 and 0.119 which is lower than the critical value we conclude that H0 is not rejected as there is insufficient evidence to conclude that there is a significant linear correlation.

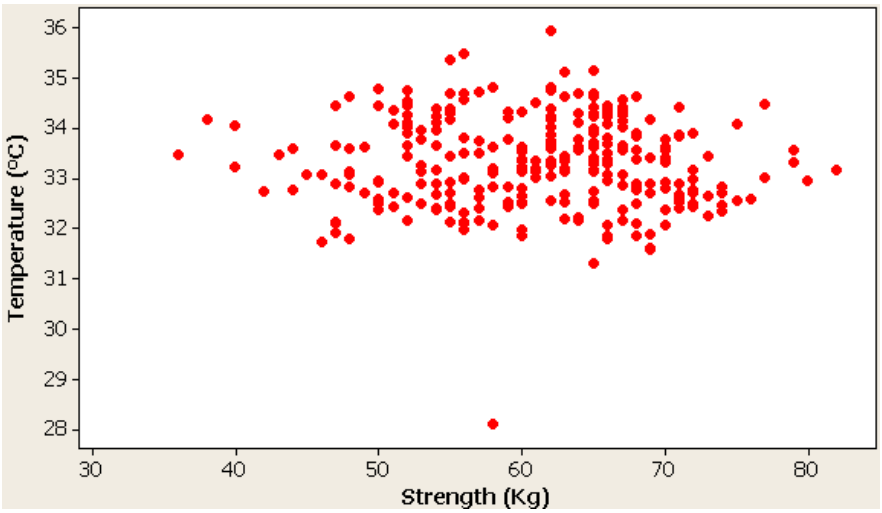

Figure 1: Correlation between Temperature (°C) and Strength (Kg) of the operator 1 in the 7 days.

In the figure 2 is shown the correlation between cycles per minute and temperature in the 7 days, where r is 0.292. As r is 0.292 and 0.119 which is greater than the critical value we conclude that there is a significant linear correlation, and H0 is rejected.

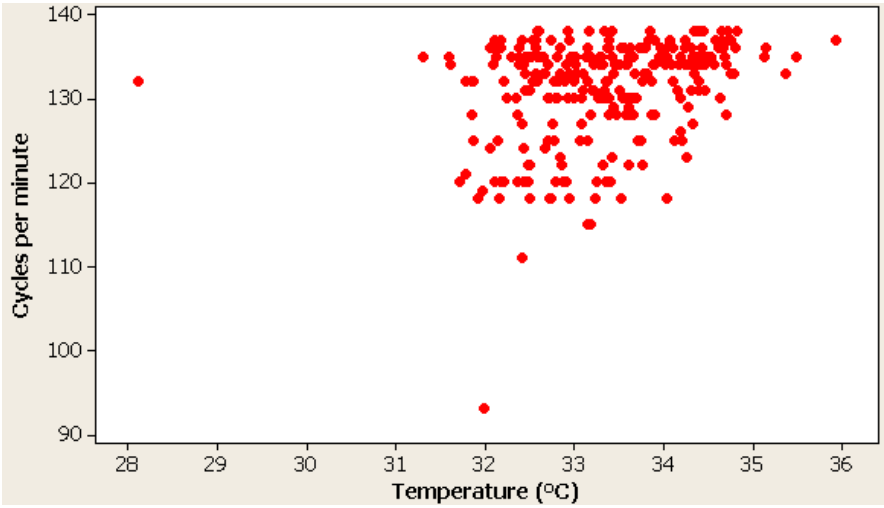

Figure 2: Correlation between cycles per minute and temperature (°C) of the operator 1 in the 7 days.

In the figure 3 is shown the correlation between cycles per minute and Power in the 7 days, with r of 0.266. As r is 0.266 and 0.119 which is greater than the critical value we conclude that there is a significant linear correlation, and H0 is rejected.

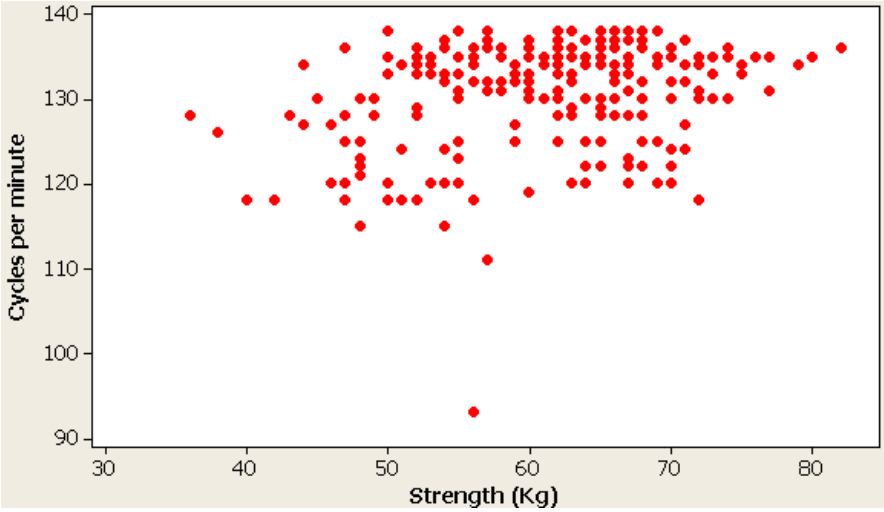

Figure 3: Correlation between cycles per minute and strength (Kg) of the operator 1 in the 7 days.

The table 3 is shown the results obtained from the variables of the operator 1 in the 7 days.

Table 3: Results of the Operator 1 variables in the 7 days.

Descriptive Statistics									
Variable	Average	Estandar Deviation	Variance	Coefficient of Variation	minimum	Q1	Median	Q3	Maximum
Cycles per min.	130.97	6.15	37.81	4.69	93	128	133	135	138
Strength Kg	61.015	8.353	69.779	13.69	36	55	62	67	82
Temperature °C	33.307	0.902	0.814	2.71	28.11	32.67	33.297	33.974	35.935

The table 4 is shown the maximum and minimum values of the variables of temperature, strength and cycles per minute generated by day to perform horizontal repetitive movement of the operator 1.

Table 4: Results of the operation range of the operator 1 per day.

Operator # 1	Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		Day 7	
	max	min	max	min	max	min	max	min	max	min	max	min	max	min
Temperature °C	34.42	32.08	35.48	33.61	34.19	31.71	34.69	28.11	34.3	31.6	34.61	31.78	35.93	32.58
Strength Kg	68	48	68	47	57	36	73	58	75	60	68	54	82	58
Cycles per minute	138	125	138	125	134	93	138	118	136	120	138	125	137	128

In the figure 4 is shown the correlation between temperature and strength in the 7 days, being r -0.072. As r is -0.072 and 0.119 which is lower than the critical value we conclude that H0 is not rejected as there is insufficient evidence to conclude that there is a significant linear correlation.

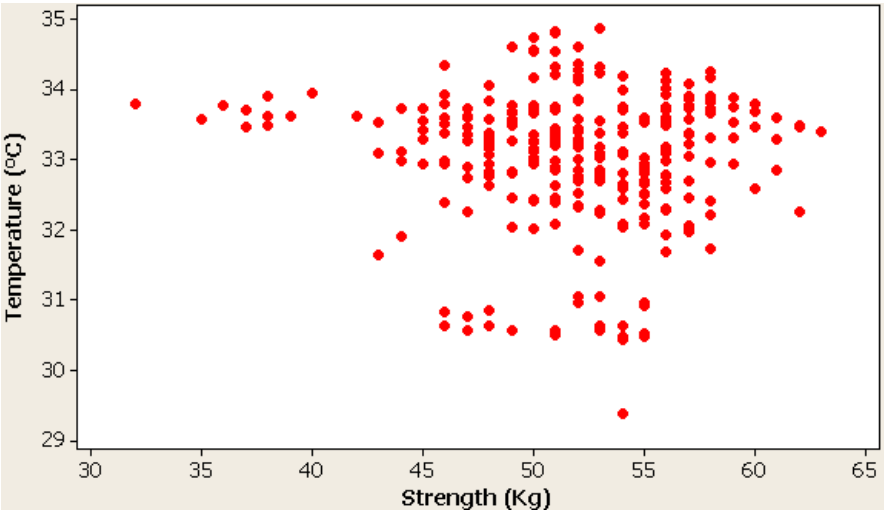

Figure 4: Correlation between Temperature (°C) and Strength (Kg) of the operator 2 in the 7days.

In the figure 5 is shown the correlation between cycles per minute and temperature in the 7 days, with r -0.172. As r is -0.172 and its absolute value is 0.172 and 0.119 which is greater than the critical value we conclude that there is a significant linear correlation, and H0 is rejected.

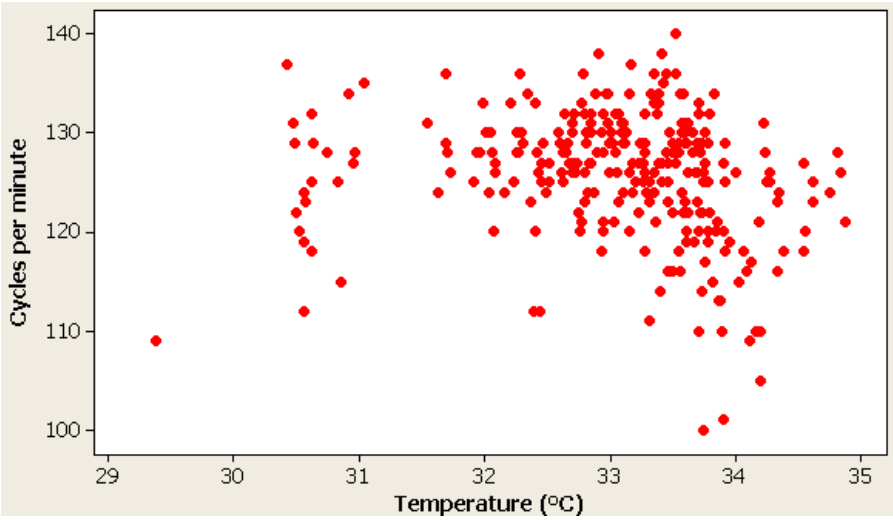

Figure 5: Correlation between cycles per minute and temperature (°C) of the operator 2 in the 7 days.

In the figure 6 is shown the correlation between cycles per minute and Strength in the 7 days, being r -0.002 As r -0.002. and 0.119 which is lower than the critical value we conclude that H0 is not rejected as there is insufficient evidence to conclude that there is a significant linear correlation.

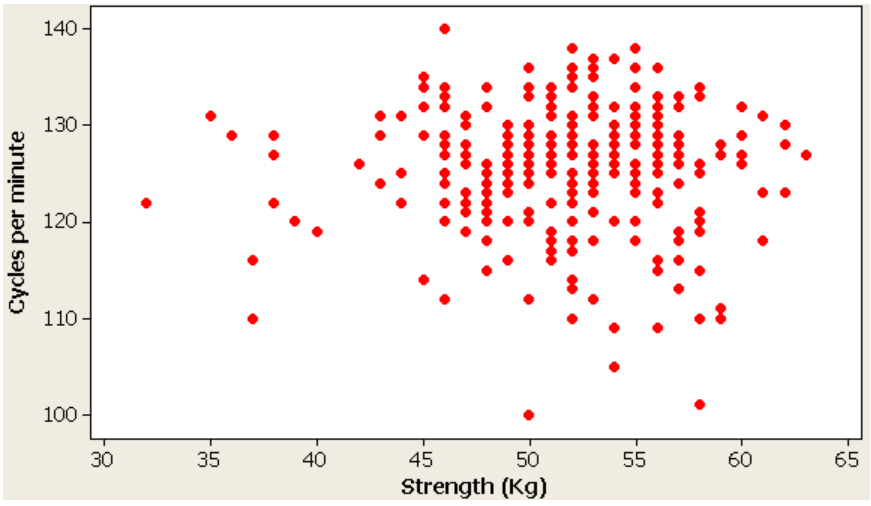

Figure 6: Correlation between cycles per minute and Strength (Kg) of the operator 2 in the 7 days.

The table 5 is shown the results obtained from the operator 2 variables in the 7 days.

Table 5: Results of the operator 2 variables in the 7 days.

Descriptive Statistics									
Variable	Average	Estandar Deviation	Variance	Coefficient of Variation	minimum	Q1	Median	Q3	Maximum
Cycles per min.	125.75	6.5	42.26	5.17	100	122	127	130	140
Strength Kg	51.74	5.111	26.12	9.88	32	49	52	55	63
Temperature °C	33.036	0.967	0.936	2.93	29.384	32.632	33.245	33.691	34.878

The table 6 is shown the maximum and minimum values of the variables of temperature, strength and cycles per minute generated by day to perform horizontal repetitive movement in the operator 2.

Table 6: Results of the operating range of the operator 2 per day.

Operator # 2	Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		Day 7	
	max	min	max	min	max	min	max	min	max	min	max	min	max	min
Temperature °C	33.95	32.85	34.85	32.75	34.878	33.32	33.402	29.38	34.27	30.43	33.84	32.01	33.23	31.71
Strength Kg	63	32	57	44	59	46	58	43	58	47	57	43	62	47
Cycles per minute	133	110	140	100	131	101	135	109	138	120	135	121	134	123

5. CONCLUSIONS

In the present study fulfilled the objective of correlating the variables temperature, strength, and cycles per minute that are manifested in the wrist area of the dominant hand (in this case the operators was the right hand) with horizontal repetitive movements during working day within a week.

On based on this study the results were as follows: *the operator 1 ,*there was a correlation in cycles per minute against temperature and against strength, besides the maximum in: temperature was 35.93°C, strength was 82 kg and cycles per minute was 138 movements and the minimum in: temperature was 28.11°C, strength was 36 kg and cycles per minute was 93 movements; *the operator 2:* there was a correlation in cycles per minute, besides the maximum in: temperature was 34.87°C, strength was 63 kg and cycles per minute was 140 movements and the minimum in: temperature was 29.38°C, strength was 32 kg and cycles per minute was 100 movements.

The conclusion was: correlation exists between temperature against cycles per minute and strength against cycles per minute; and there is no correlation between temperature and strength.

6. REFERENCES

Beevis, D., (2003). Ergonomics-Costs and Benefits Revisited. *Applied Ergonomics 34:* 491-496.

Derango, K. and Franzini, L., (2002). Economic Evaluations of Workplace Health Interventions: Theory and Literature Review. *In Handbook of Occupational Health Psychology,* Ed Washington D.C. American Psychological Association.

Ferreira, J., Mendonça, L.C., Nunez, L.A., Andrade, A.C., Rebelatto J.R., and Salvini, T. (2007). Exercise-Associated Thermographic Changes in Young and Elderly Subjects, Federal University of Saint Carlos. *Physics' Institute* of Saint Carlos, Sao Paulo University, Brazil.

Gold E. J., Cherniack M., Buchholz B., (2004). Infrared Thermography for examination of skin temperature in the dorsal hand office workers, *Eur J. Apply Physiol 93*: 245-251.

Hendrick, H.W., (2003). Determining the Cost-Benefits of Ergonomics Projects and Factors that lead to their Success. *Applied Ergonomics 34:* 419-427.

International Training Center of the International Labor Organization. ITCILO: Home page. http://www.itcilo.it/actrav/osh_es/módulos/ergo/ergoa.htm

Kyeong-Seop, K., Shin, S.W., Yoon, T.H., Kim, E.J., Lee, J.W. and Kim, I.Y. (2006). Infrared Thermography in Human Hand", *School of Biomedical Engineering*, Chungju, Korea.

Ming, Z., Zaproudina, N., Siivola, J., Nousiainen, U., Pietikainen S., (2005). Sympathetic pathology evidenced by hand thermal anomalies in carpal tunnel syndrome, *ISP Pathophysiology*: 137-141.

International Labor Organization (2004). Labor Productivity in Latin America, is the same as 20 years ago, *Magazine of occupational panorama of the OIT*.

Sinclair, D.T. and Graves, R.J. (2001). Feasibility of Developing a Simple Prototype Decision Aid for the Initial Medical Assessment of Work Related Upper Limb Disorders. University of Aberdeen. Department of Environmental & Occupational Medicine. *Hse Books*.

Shooting Sport Club La Rioja, Shooting Sport Club La Rioja Home page: http://www.tiroriojano.com/lesiones/EPICONDILITIS.htm

Tchou, S.F., Costich, J.C. Burguess, R., Lexington, K.Y. and Wexler C. (1992). Thermographic observations in unilateral Carpal Tunnel Syndrome: Report of 61 cases, *The Journal of the hand surgery 17A*: 631-637.

Tortosa, L. and Garcia, C., Page, A. and Ferreras, A. (1999). Ergonomics and disability. *Institute of Biomechanics of Valencia* (IBV), Valencia. ISBN 84-923974-8-9.

U.S. National Library of Medicine and National Institutes of Health. Medical Encyclopedia: Home page. http://nlm.nih.gov/medlineplus/ency/article/001242.htm

Zontak, A., Sideman, S, Verbitsky, O. and Beyar, R., (1998). Dynamic Thermography: Analysis of hand temperature, *Annals of Biomedical Engineering, Vol. 26,* 988-993.