

# Maximum force levels in different positions of shoulder and elbow

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**Abstract.** The number of occupational diseases in Mexico is alarming and clearly it is important to do studies with the purpose of improving the design of workstations. The objective of this research is to determine the maximum force levels in different positions of shoulder and elbow. An experiment was conducted with 16 subjects between 18 and 28 years old: 8 male and 8 female. We considered 16 different positions, working with the right and left arm to perform the tasks of pull and push. The tasks consisted of pushing or pulling a dynamometer for a period of 3 seconds as hard as possible. The results were presented in tables. The tables show the mean, standard deviation and range of force levels in different positions.

Keywords: Arms, Posture, Lateral, Frontal.

## 1. Introduction

Firms perform activities aimed at the prevention of occupational diseases; the results will be reflected in the production and productivity, as well as in better working environment and workers wellbeing. According to statistics from the Mexican Institute of Social Security (IMSS) during 2009 there were 4,101 new cases of occupational diseases in Mexico. No doubt this is alarming and clearly it is important to do studies with the purpose of improving the design of workstations.

The objective of this research is to determine the maximum force levels in different positions of shoulder and elbow.

## 2. Materials and Method

### 2.1. Subject

An experiment was conducted with 16 people between 18 and 28 years old: 8 male and 8 female. The

participants were bachelor's degree students without manual material handling industrial abilities and they assure not to have any physical problem. Anthropometric measurements of the subjects were taken. The height was between 153.5 cm and 185.4 cm (mean = 166.6, SD = 9.2501 cm) and the weight between 47.0 kg and 100.7 kg (mean = 66.55 kg, SD = 14.0639 kg).

### 2.2. Tasks

The postures studied in the experiment were as follows: angles of 0°, 20°, 45° y 90° for lateral and frontal inclination. It considered 16 different positions, working with the right and left arm to perform the tasks of pull and push, resulting in participants doing 64 different tasks. The tasks consisted of pushing or pulling a dynamometer as hard as possible for a period of 3 seconds, the subjects would rest for 1 minute and then they would perform another pushing or pulling in a different position.

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2.3. Procedure

The participants received instructions about the tasks to be performed. They were instructed to work as hard as possible without straining themselves or becoming unusually tired, weakened, overheated or without of breath. Subjects performed the experiment in 4 sessions. The tasks per session were as follows:

- First session: 0° angle of lateral inclination. 16 tasks (with 0°, 20°, 45° and 90° angle of frontal inclination; pushing and pulling; left and right arms), 3 replicates per task.
- Second session: 20° angle of lateral inclination with 16 tasks.
- Third session: 45° angle of lateral inclination with 16 tasks.
- Fourth session: 90° angle of lateral inclination with 16 task.

The duration of each session was approximately 56 minutes. There was only one session per day in order to avoid fatigue in people.

3. Results and discussions

Tables 1 and 2 present the results of the experiment. For women the maximum values of force for the tasks of pulling and pushing were obtained at 45° of lateral inclination. For men, the maximum values were presented at 45° of lateral inclination for pulling and 0° lateral inclination for pushing. 90° of frontal inclination was the position associated with highest force for men and women in pushing and pulling. Men were stronger than women in the 64 tasks. Pulling required higher forces than pushing for men and women.

Table 1  
Male maximum force

Posture	Arm (Left, Right)	Pushing (Newton)			Pulling (Newton)		
		Mean	SD	Range	Media	SD	Range
Lateral 0° - Frontal 0°	L	67.8654	22.9911	30.3986 - 100.3477	73.7490	23.7442	38.8965 - 107.2119
	R	68.3557	24.5729	34.3210 - 100.6743	76.8545	23.0019	36.2822 - 106.8854
Lateral 0° - Frontal 20°	L	62.3495	22.1272	20.2651 - 82.6969	72.4418	24.2953	24.5150 - 101.3283
	R	62.1857	24.6062	16.6702 - 86.9459	75.0561	26.1006	19.6120 - 98.7131
Lateral 0° - Frontal 45°	L	66.2719	19.9935	29.4180 - 90.5417	78.7745	23.5383	32.6863 - 102.6355
	R	65.6590	22.7803	25.8221 - 91.8489	76.1593	22.9657	27.7833 - 95.7713
Lateral 0° - Frontal 90°	L	75.5876	32.1666	27.1293 - 131.7269	95.1182	39.3279	32.3598 - 158.8572
	R	74.4844	30.3574	21.8997 - 120.9403	93.3208	36.2077	23.8609 - 146.1094
Lateral 20° - Frontal 0°	L	64.8824	21.8742	29.7445 - 87.5999	80.4494	26.2320	33.3404 - 105.5773
	R	60.5109	23.3402	19.9385 - 86.2928	78.3254	24.9043	26.4762 - 99.3671
Lateral 20° - Frontal 20°	L	65.9042	25.6760	20.5926 - 96.0988	78.0803	26.6017	26.4762 - 105.9048
	R	67.4163	22.8293	26.1487 - 94.7907	76.8947	23.0117	26.8027 - 95.7713
Lateral 20° - Frontal 45°	L	70.1943	28.0334	23.2069 - 104.5967	76.6094	22.6538	33.3404 - 98.7131
	R	68.7646	24.2885	26.1487 - 97.7325	77.3850	23.5305	26.8027 - 102.6355
Lateral 20° - Frontal 90°	L	66.8848	24.0933	32.6863 - 99.3671	85.1073	21.9478	44.4535 - 112.1149
	R	70.1129	22.6597	36.9353 - 104.9242	85.1073	19.6287	48.0494 - 109.1731
Lateral 45° - Frontal 0°	L	64.5970	23.8266	25.4956 - 92.8295	82.3704	27.4539	33.3404 - 118.6526
	R	62.3907	22.9931	25.8221 - 86.2928	81.8389	26.9538	28.4374 - 107.5385
Lateral 45° - Frontal 20°	L	62.0632	21.3673	25.1681 - 89.8877	79.4286	27.1783	24.8415 - 112.1149
	R	60.6746	21.6615	25.1681 - 96.0988	79.5914	22.2253	29.4180 - 98.7131
Lateral 45° - Frontal 45°	L	59.1214	19.1766	22.8803 - 86.6193	80.8583	24.7651	31.0517 - 117.3445
	R	65.4551	24.9033	25.1681 - 107.2119	81.3898	23.4216	32.6863 - 111.7884
Lateral 45° - Frontal 90°	L	61.5327	24.2826	24.1875 - 104.5967	82.1253	26.5311	30.3986 - 118.6526
	R	70.4394	29.5543	24.5150 - 126.1699	83.6775	25.2289	33.9935 - 112.4415
Lateral 90° - Frontal 0°	L	64.1067	27.7951	20.9191 - 105.9048	74.8521	33.1207	22.8803 - 127.4780
	R	62.3093	26.2124	21.8997 - 102.9630	73.7490	31.3262	25.4956 - 120.9403
Lateral 90° - Frontal 20°	L	59.5715	25.4270	18.3039 - 95.1182	77.6714	24.8886	36.2822 - 116.6914
	R	61.6552	24.4905	19.9385 - 97.4059	74.8933	25.9682	32.0323 - 109.8272
Lateral 90° - Frontal 45°	L	63.3713	25.4377	20.9191 - 98.0600	81.7575	31.7293	26.1487 - 118.6526
	R	67.0485	26.2958	26.4762 - 100.3477	79.1835	28.7737	26.4762 - 110.8078
Lateral 90° - Frontal 90°	L	77.0585	35.2859	22.5538 - 128.1311	89.0708	27.7490	46.7413 - 124.2087
	R	77.5900	33.8278	26.8027 - 115.7108	85.1484	28.7924	41.8383 - 130.4198

Table 2  
Female maximum force

Posture	Arm	Pushing (Newton)			Pulling (Newton)		
		Mean	SD	Range	Media	SD	Range
Lateral 0° - Frontal 0°	L	37.2628	16.6133	23.5344 - 70.6032	42.8199	7.4045	30.3986 - 50.3371
	R	35.8321	14.1785	24.1875 - 64.7196	43.3504	9.7746	31.3792 - 55.2401
Lateral 0° - Frontal 20°	L	32.7677	12.2163	19.2845 - 51.6443	36.8951	10.3179	18.6314 - 53.2789
	R	32.2372	11.3769	18.6314 - 53.2789	39.2642	10.1129	27.1293 - 52.6249
Lateral 0° - Frontal 45°	L	37.9159	15.5278	24.1875 - 69.6226	41.3892	11.9751	22.8803 - 56.5473
	R	36.4862	12.6282	25.8221 - 57.8554	43.3504	12.8978	27.4568 - 62.1043
Lateral 0° - Frontal 90°	L	45.8019	12.3683	32.0323 - 67.9879	55.1588	11.9104	41.8383 - 80.7357
	R	47.7219	12.5576	30.7251 - 70.2757	57.8142	15.8945	36.6087 - 92.8295
Lateral 20° - Frontal 0°	L	36.7313	13.6823	15.0355 - 55.2401	47.8445	18.9030	15.3621 - 76.8133
	R	37.3854	13.4430	16.3427 - 55.5667	51.0726	22.6313	16.6702 - 86.6193
Lateral 20° - Frontal 20°	L	39.1014	14.8031	15.0355 - 59.4891	46.8237	17.1105	13.4009 - 70.6032
	R	39.2240	13.5450	20.5926 - 53.9330	49.0702	20.6456	15.0355 - 80.0817
Lateral 20° - Frontal 45°	L	40.0408	16.4780	16.3427 - 62.1043	50.3371	17.4782	18.6314 - 72.2369
	R	39.5505	16.4780	17.6508 - 58.5085	48.2534	20.2445	16.6702 - 75.8327
Lateral 20° - Frontal 90°	L	41.3892	16.6163	20.2651 - 63.0849	51.8080	17.2439	26.1487 - 80.4092
	R	41.3490	17.7930	24.5150 - 64.7196	51.1138	17.2556	28.7639 - 83.3510
Lateral 45° - Frontal 0°	L	39.7143	10.4787	27.7833 - 58.8360	55.2813	20.6573	37.2628 - 90.2152
	R	42.4923	11.3230	30.3986 - 60.4697	55.9344	22.2106	38.8965 - 95.1182
Lateral 45° - Frontal 20°	L	41.5931	15.2915	21.8997 - 62.7584	55.9756	22.3714	28.4374 - 91.8489
	R	40.8577	14.6364	19.2845 - 59.1625	56.8336	22.0253	32.0323 - 91.5223
Lateral 45° - Frontal 45°	L	40.6949	15.0453	24.1875 - 68.6420	54.2184	21.7036	25.8221 - 87.2734
	R	41.8795	15.4003	25.4956 - 63.7390	55.9354	20.5808	32.6863 - 87.2734
Lateral 45° - Frontal 90°	L	43.3504	13.0371	28.1099 - 65.0461	56.1796	15.8524	36.6087 - 82.0429
	R	44.3310	16.5045	27.1293 - 73.5450	57.0788	18.9128	39.8771 - 95.4447
Lateral 90° - Frontal 0°	L	37.7933	9.9698	21.8997 - 50.9912	49.8880	18.4902	21.2457 - 84.0041
	R	37.0177	10.7856	21.8997 - 50.6637	45.1478	16.8487	20.9191 - 73.8715
Lateral 90° - Frontal 20°	L	35.9145	11.2779	21.8997 - 58.5085	45.6793	15.3444	23.2069 - 78.1205
	R	35.6281	11.7309	22.5538 - 53.9330	45.8431	16.5859	29.7445 - 78.1205
Lateral 90° - Frontal 45°	L	39.5094	9.4255	26.1487 - 52.9524	48.1720	15.0189	24.1875 - 74.1981
	R	37.6707	11.2847	25.1681 - 53.6055	48.0896	16.3731	26.1487 - 76.1593
Lateral 90° - Frontal 90°	L	40.4086	13.7206	24.1875 - 61.1237	60.2245	17.7940	30.3986 - 90.5417
	R	42.7787	12.2232	30.3986 - 62.1043	64.0244	19.9689	36.6087 - 96.4253

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