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# Determinants of Grip Strength in Tunisian Nurses: A Bicentric Study



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**Abstract: Background:** Grip muscle force has always been used to assess functional limitations in elderly. Its use as a tool to assess work capacity has never been described in the literature.

**Objective:** To describe the patent determinants of grip strength and the usefulness of its measurement in assessing workability index in the healthcare sector.

**Methods:** This is a cross-sectional study conducted in a sample of 293 healthcare workers representative of 1181 based on a comprehensive questionnaire about socio-professional characteristics and on an 8-item work capacity evaluation (WAI). Besides, Body mass index was measured and muscle strength was assessed by JAMAR hydraulic dynamometer.

**Results:** Handgrip Strength was stronger in male nurses ( $p < 0.001$ ), with low perceived physical load ( $p = 0.0001$ ) and working on a night shift ( $p = 0.001$ ). It decreased with a greater duration of household work ( $p < 0.0001$ ) and increased with a greater BMI ( $p = 0.015$ ) and a better workability index ( $p < 0.0001$ ). After removal of all the variables that were not independently associated with the muscle strength force, factors accounting for 52.6% of the variance in nurses handgrip strength were gender ( $p < 0.001$ ), workability index ( $p < 0.001$ ), duration of household work ( $p = 0.021$ ), BMI ( $p = 0.002$ ), perceived physical load ( $p < 0.001$ ) and work schedule ( $p = 0.002$ ).

**Conclusion:** Grip Strength Test is a useful tool to assess strength and functional capacity at work in healthcare workers. Further longitudinal studies are required to confirm this hypothesis.

**Keywords:** Dynamometer, ergonomics, grip strength, health occupations, nurses, premature aging, work capacity evaluation.

## INTRODUCTION

Muscle force is fundamental to perform any manual work. In literature, it seemed to be correlated to the age and the global muscle force [1-5].

Its assessment may be useful to assess work capacity as well as it has been for the assessment of functional limitations in elderly people [6-8].

In fact, up to now, grip strength test has been used to assess functional limitations in elderly people and for screening for muscle function loss in the elderly [9, 10].

Yet, in occupational field, we are usually accustomed to use the medical examination to assess medical ability to work and we have no simple ergonomic tool to assess physical capacity to screen for physical premature aging.

Moreover, the field of Healthcare workers is characterized by a mental, organizational and physical strain that could influence this physiological performance. In fact,

considering the variability of tasks in a hospital, a healthcare worker is required not only to be skillful but strong too. One of the main obstacles in assessing workability is the lack of tools for its evaluation except the medical ones.

This study sets out to investigate the determinants of grip strength and its usefulness in the workability index in the healthcare sector

## METHOD

**Participants:** A sample of 293 healthcare workers representative of 1181, working in two Tunisian university hospitals.

**Study design:** This is a cross-sectional study performed during a fourteen-month period. The sample was drawn by stratified sampling in two stages by gender and department.

**Data collection:** In an attempt to standardize the data collection, four previously trained interviewers administered a comprehensive anonymous set of questionnaires and measured, grip strength force, height, weight and calculated the body Mass Index (BMI) for each participant. Before each evaluation, a written informed consent was obtained and the



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rights of the subjects were protected; besides a dominant-hand joint disorder was systematically sought. Seventy four had this sort of disorder and were excluded from the study. We finally got 219 participants.

In order to determine whether the muscle force was influenced by work capacity at work in the health care system, many variables have been assessed:

- The Workability index: the workability is a frame work that has been implemented by the Finnish Institute of Occupational Health since the mid-1980s [11, 12]. It is a validated self-assessment questionnaire containing seven items measuring subjective perceptions including:

1) Current workability compared to lifetime best; 2) Current workability according to mental and physical demands of work; 3) Diagnosed diseases; 4) Subjective health status; 5) Impact of health problems on current work capacity; 6) Extent of impairment (work rest in the last 12 months); 7) Expectations of working 2 years from now;

This tool has been validated in a large population of 40 000 Finnish nurses [13, 14]. Moreover, applied to a representative sample of 5800 persons, it found in the Finnish Health 2000 survey a relationship between low workability measures and exit due to disability [15]. Work capacity levels are listed in 4 classes according to the workability index results:

1) Poor work capacity: 7-27 Points; 2) Average Work capacity: 28-36 Points; 3) Good work capacity: 37-43 Points; 4) Excellent work capacity: 44-49 Points.

- The body mass index (BMI): Expressed in kg/m<sup>2</sup>, the BMI evaluates the degree of obesity and thus allows evaluating the health risks associated with it. According to the World Health Organization classification [16], obesity classes are:

1) Lean subjects: BMI <18.5kg/m<sup>2</sup>; 2) Subjects with normal weight: 18.5 ≤ BMI <25kg/m<sup>2</sup>; 3) Subjects with overweight: 25 ≤ BMI <30kg/m<sup>2</sup>; 4) Obese: BMI ≥ 30kg/m<sup>2</sup>

- The Grip Strength Test: aims to measure the maximum grip force by a JAMAR hydraulic hand dynamometer (Patterson, Nottinghamshire, United Kingdom) displaying grip force in kilograms up to 90 kilograms [17, 18].

The nurse was asked to apply a gripping force by its dominant hand on the dynamometer. Final results were expressed in Kilogram (Kg).

As for the perceived physical and mental workloads, the participant was asked to categorize their workload respectively on the mental and on the physical sides according to 2 grades: slight or heavy.

We also assessed the weekly duration of physical leisure and domestic activity in hours through a simple question asked to nurses.

Additionally, in order to study the influence of seniority in shift work and in night work on the variability of the grip strength, two indexes have been created:

- An index of seniority in shift work = seniority in shift work / total seniority.
- An index of seniority in night work = seniority in night work / total seniority.

Data analysis: The results of our study were analyzed by SPSS 21 software. Descriptive statistics were used to describe the population characteristics by calculating the frequencies and the percentages for categorical variables on the one hand, and the means, standard deviations and extent of extreme values for quantitative variables on the other hand. Regarding the multivariate analysis, we used a multiple linear regression. The inclusion of independent variables in the regression models was made when the significance level was less than 0.25. For statistical tests; the significance level  $p$  was set at 0.05.

## RESULTS

Sex ratio of our population study was 1.21. Distribution according to age showed 2 peaks around thirty and fifty five years (Fig. (1)).

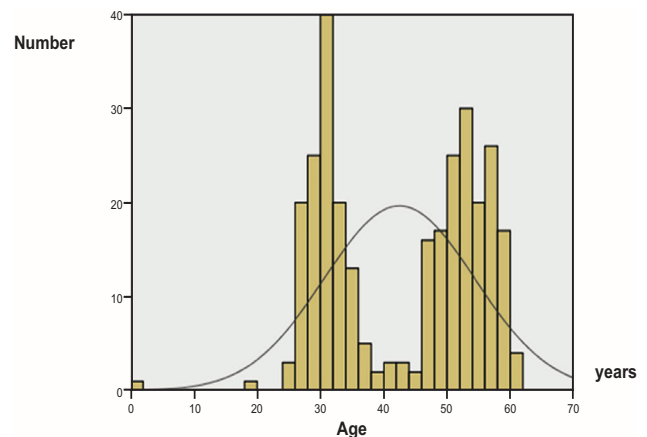


Fig. (1). Study population distribution according to age.

### Socio-Demographic Characteristics

Men ( $p < 0.001$ ), and non-smoking men ( $p = 0.003$ ) had a greater maximal isometric handgrip strength. (MIHS).

Moreover, the longer the duration of physical activity was ( $\beta = 0.187$ ,  $p < 0.005$ ), the better the muscle strength was in our study population. Nevertheless, domestic activity decreased muscle force strength in our subjects ( $\beta = -0.392$ ,  $p < 0.0001$ ). Additionally, higher strength was associated to a greater Body Mass Index ( $\beta = 0.2$ ,  $p = 0.015$ ) (Table 1).

### Professional Characteristics

Table 2 displays the ANOVA test and matched pairs t-test which revealed a statistically significant increase in MIHS in night shift workers ( $p = 0.001$ ) and in nurses with high perceived physical ( $p = 0.0001$ ) workload.

Moreover, univariate linear regression tests revealed that workability index ( $p = 0.0001$ ;  $\beta = 0.41$ ), Index of seniority

**Table 1. Variation of Maximal Isometric Handgrips Strength According to Socio-Demographic Characteristics.**

		Mean (kg)	N	$\beta$	P value
Gender	Male	68.60 $\pm$ 22.40	120		<0.0001
	Female	44.91 $\pm$ 16.64	99		
Smoking**	No	70.88 $\pm$ 24.07	59		0.003
	Former	64.75 $\pm$ 22.86	40		
	Yes	56.11 $\pm$ 19.71	52		
	No x Former				0.37
	No x Yes				0.002
	Former x Yes				0.16
Diploma	Elementary	40.68 $\pm$ 12.84	19		0.176
	Secondary	64.48 $\pm$ 23.21	111		
	Nursing diploma	53.68 $\pm$ 22.25	74		
	university	51.60 $\pm$ 21.63	15		
Age (years)		41.80 $\pm$ 12.13		0.072	0.467
B M I		26.704 $\pm$ 3.83		0.2	0.015
PAD (hours/week)		3.54 $\pm$ 6.69		0.187	0.005
DAD (hours/week)		14.69 $\pm$ 15.64		-0.392	<0.0001

N: Number of subjects, Mean (kg): Mean value of muscle voluntary contraction in kilograms,

BMI: Body mass index, PAD: Physical activity duration (hours/week), DAD: Domestic activity duration (hours/week).

\*\* : Smoking in men because none of the women was a smoker.

in night work ( $p = 0.002$ ;  $\beta = 0.209$ ) were statistically correlated to muscle force (Table 2).

### Multivariate Model of Correlates of Upper Body Muscle Strength Among Healthcare Workers

Multivariate regression correlates of upper body muscle strength are displayed in Table 3.

The determinants of hand grip strength were tested in linear regression models adjusting for potential confounding variables. After removal of all the variables that were not independently associated with the muscle strength force, factors accounting for 52.6% of the variance in handgrip strength were gender ( $p < 0.001$ ), workability index ( $p < 0.001$ ), duration of household work ( $p = 0.021$ ), BMI ( $p = 0.002$ ), perceived physical load ( $p < 0.001$ ) and work schedule ( $p = 0.002$ ) (Table 3).

### DISCUSSION

Our study shows that many socio-professional determinants influence the upper limb muscle force in healthcare workers. Gender was the first determinant of MIHS in our study population. In fact, men seem to have a stronger muscle force in the upper limb than women ( $p < 0.0001$ ) which is in accordance with the findings of previous studies in the general population [2-5, 19].

Despite the proof mentioned in the literature review showing the influence of age on muscle strength decline, our study did not find any statistical relation between aging in nurses and the maximal strength force [4, 20]. In fact, muscle strength and mass reduction among elderly are mainly attributed to "sarcopaenia" phenomenon [21].

The lack of MIHS decrease with ageing in nurses, could be explained by the specificity of the job demand of manual dexterity. In fact, the practice of care acts as it is usually performed in healthcare field can maintain acceptable hand grip strength despite ageing.

Additionally, Body Mass Index influenced positively our healthcare workers grip strength in the univariate analysis and was a part of the final multi correlates model in our study. This may be explained by the increase in the body fat percentage which might decrease the handgrip endurance but not the handgrip strength. This finding corroborates with those of Rebecca Hardy [22], who showed that higher BMI was associated with stronger grip strength in men in a cross-sectional data from eight UK cohort studies. Prior studies have even shown that muscle force and BMI could be used as long-term predictors of mortality in 6040 participants [23-25].

Concerning joint disorders of the dominant hand, they really may lead to developing pain during the Hand Grip Test and may oblige individuals to reduce the pushing effort.

**Table 2. Variation of Maximal Isometric Handgrips Strength According to Professional Characteristics.**

		Mean(kg)	N	β	P value
Type of department	With high workload	57,96±22.78	95		0.965
	With lower workload	57,83±23.60	124		
Function	Nurse	58,39±23,06	200		0.417
	Healthcare technician	50,33±23,23	15		
	Healthcare auxiliary	61±31,20	4		
Work schedule	Day time	52,07±22,81	83		0.001
	Shift time	58,95±22,50	108		
	Night time	71.03±21,67	28		
PPL	Slight	42.58±14.41	17		< 0.0001
	Heavy	59.17±23.36	202		
PML	Slight	48.33±19,34	15		0.067
	Heavy	58.59±23.34	204		
Psycho-social factors at work	LSJ	55.78±23,92	23		0.216
	AJ	62.07±24,15	80		
	PJ	52.60±19,85	20		
	HSJ	56.01±22,65	96		
	LSJ x PJ				0.68
	LSJ x AJ				0.88
	LSJ x HSJ				0.85
	AJ x PJ				0.18
	AJ x HSJ				0.08
	PJ x HSJ				0.91
WAI		40.00±6.28		0.41	< 0.0001
Seniority (years)		18.45±13.09		0.02	0.76
Index of seniority in shift work		5.01±7.04		0.06	0.31
Index of seniority in night work		5.63±7.53		0.209	0.002

N: Number of Subjects, WAI: Work Ability Index, PPL: Perceived Physical Load, PML: Perceived Mental Load  
 Lowstrain Job: LSJ; Active Job: AJ; Passive Job: PJ; High Strain Job: HSJ

**Table 3. Multivariate Model of Correlates of Upper Body Muscle Strength Among Healthcare Workers (N = 219).**

Determinants of muscle strength	β	t	95,0% Confidence Interval for B		r <sup>2</sup>	p
			Lower Bound	Upper Bound		
Gender	0.34	4.92	9.50	22,21	0.526	0.000
BMI	0.15	3.15	0.34	1.48		0.002
DAD	-2.32	0.02	-0.44	-0.03		0.021
WAI	0.34	7.09	0.97	1.72		0.000
Work schedule	0.15	3.11	1.90	8.49		0.002
PPL	0.26	5.56	6.32	13.278		0.000
Model summary					0.526	

BMI: Body Mass Index, DAD: Domestic Activity Duration, WAI: Work Ability Index  
 PPL: Perceived Physical Load

That is why we decided to exclude patients with dominant-hand disorders from the study. In contrast, findings of earlier studies performed on elderly patients in geriatrics and in physical rehabilitation departments, were unable to demonstrate any significant association between hand joint disorders and the hand grip strength [26, 27].

Next question in the research was to find whether regular physical activity in nurses could influence the muscle strength. It is interesting to note that physical activity was significantly associated with muscular strength in our healthcare workers ( $p = 0.005$ ) even if it did not last in the multivariate model regression.

Divergent findings on relationship between muscle strength and physical activity have been reported in the literature. In fact, while Paalane [28] found in a study performed among 874 healthy young men and women, that lack of physical activity was associated with poor muscular fitness measured by a computerized dynamometer, Leblanc concluded in a study conducted on 412 over-20-year healthy men and women that physical activity accounted for only 1-3% of the variance in muscle strength measured by a hand-grip dynamometer [26].

Surprisingly, the number of hours of weekly household work was found to be a predictor of decline of grip strength ( $p < 0.0001$ ,  $\beta = -0.392$ ) and explained 15.4% of this decline. The duration of weekly household work lasted in the multi regression model which was adjusted to gender variable. A possible explanation for the significant relation between this variable and the grip strength could be the specificities of household work strain for Tunisian women, which includes a great musculoskeletal strain with a weekly spring-cleaning and at least two daily hours to prepare meals in the evening. These variables were shown to be a predictor of upper limb musculoskeletal disorders in an ergonomic study carried out on female textile industry workers in Tunisia [29].

On the other hand, in the current study, the professional variables influencing the grip strength in healthcare workers were: work schedule ( $p = 0.001$ ), perceived physical load ( $p = 0.000$ ), workability index ( $p = 0.0001$ ) and index of seniority in night work ( $p = 0.002$ ). It is very important to identify professional variables in order to better design and implement tailored prevention programs that are evidence informed.

Actually, very little was found in the literature on the question of maximal muscle strength according to occupational activity. K Walker-Bone [30], showed that there was no relationship between heavy work and greater grip Strength at retirement age, in 1418 men who had worked for at least 20 years, while Anne Moller [31], found that a history of physical job strain explained only a minor part of the variations in Hand Grip Strength in 3843 Danes.

In contrast with those of earlier studies, our findings showed that muscle force was stronger in night-shift workers ( $p = 0.001$ ) and increased with the index of seniority in night work ( $p = 0.002$ ,  $\beta = 0.20$ ).

It could be explained by the lack of staff during night shifts, which keeps workers in constant motion, and by versatility of tasks including medication administration, laying infusions, injections or mobilizing patients [31, 32]. The

significant association between muscular strength force and work ability index in nurses was the most interesting finding in this study ( $p < 0.001$ ,  $\beta = 0.41$ ), suggesting that the decrease of muscular strength in our population study could be related to the deterioration of workability index. The mechanism explaining how the muscular strength provides information about functional capacity remains a little bit fuzzy. Nevertheless, using a simple and easily administered tool as JAMAR Dynamometer for the upper extremity would provide useful information about work capacity in nurses [33].

In a review of the literature in 2008, Glen P [34], reported an average decline of 20% in physical work capacity between the ages of 40 and 60 years, due to decreases in aerobic and musculoskeletal capacity. Moreover, in 996-nurse- study population, Fischer [35], found that the nursing occupation was associated with stressful working conditions and contributed to inadequate WAI. These results are consistent with those of the European NEXT study population suggesting that shift schedule organization in nurses may promote their workability [36].

The participants with heavy physical perceived load had a statistically better muscle force ( $p < 0.0001$ ).

A possible explanation for this might be that those are the ones to actually undergo a physical job strain as intense as they perceive.

Although these results differ from those of some published studies [29, 30], they are consistent with those of Leblanc who showed that one of the strongest correlates of upper body strength including handgrip strength was physical activity [21, 30, 31].

Moreover, this study has been unable to demonstrate that psychosocial factors at work according to Karasek scale or the perceived mental load, affect grip strength. These results differ from MEHTA's [37] 2014 estimate of muscle strength loss and endurance time according to stress. They either do not support those of POORNIMA [38] in his Study of the Effect of Stress on Skeletal Muscle Function in Geriatrics conducted in 2014.

Multivariate regression correlates of muscle voluntary contraction in our sample of healthcare workers were gender ( $p = 0.000$ ), BMI ( $p = 0.002$ ), number of weekly hours of household work ( $p = 0.021$ ), workability index ( $p = 0.000$ ), work schedule ( $p = 0.002$ ), perceived physical strain ( $p = 0.000$ ). These factors are accounting in 52.60% of the variance of the hand grip strength in healthcare workers.

Strength testing of the injured hand is of the immense interest to injured patients and treating physicians. Another use would be the assessment of physical capacity in the work place.

Our results suggest that assessment of physical performance based on muscle force could be used to evaluate the functional capacity at work in healthcare workers. Further longitudinal studies in the healthcare work sector are required to establish this relationship. Moreover, the comparison between JAMAR tool and other devices assessing hand strength would be relevant. In fact, many multi-functional hand strength assessment devices permitting the quantification of grip hand strength are available and should be vali-

dated. These devices permit quantification of three aspects of hand strength: grip strength, finger pinch strength and twisting strength. Their use in the assessment of physical capacity would be more appropriate [18, 27].

## CURRENT & FUTURE DEVELOPMENTS

Considering our findings and the data of the literature, Grip strength test could be used to assess premature physical capacity limitations in the labour force. It could be a simple ergonomic tool to assess physical capacity to screen for physical premature aging. Further longitudinal assessment of muscle strength based on the same tool and with exactly the same population will provide more information about grip strength cut points and about the relationship between healthcare work and premature physical capacity decline. Moreover, the comparison between many occupational sectors would be useful to assess the muscle force loss in relationship with occupational sector specificities.

## CONFLICT OF INTEREST

None of the authors had any commercial relationships, which may lead to a conflict of interest.

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## PATIENTS' CONSENT

Patient consent forms have been collected before beginning the survey.

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