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ORIGINAL

Protocol for assessing physical fitness at work: methodological proposal

Protocolo para evaluar la aptitud física en el trabajo: propuesta metodológica

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ABSTRACT

As of the date of this academic work, in Venezuela it is not uncommon to place workers in jobs under inadequate conditions for their physical and mental capacity, which makes it difficult to prevent accidents at work, control unsafe conditions and occupational diseases. The Venezuelan medical/ergonomic literature does not contain a body of doctrine on the evaluation of physical fitness for work: aerobic capacity, body mass index, heart rate at rest, blood pressure. Objective: to present a methodological proposal to evaluate physical fitness for work. Paradigm: quantitative, methodology: bibliographic design, type of research: secondary documentary, level: explanatory/projective, modality: special project, which meets specific needs to obtain/interpret suitable values. Results: a protocol to collect anthropometric/physiological data, which constitutes a novelty that contributes to ergonomically evaluate the physical fitness of the Venezuelan working population, is a useful pedagogical resource as an instruction manual.

Keywords: Protocol; Physical Fitness; Work; Work Capacity Evaluation; Measurements.

RESUMEN

A la fecha de la realización del presente trabajo académico, en Venezuela no es raro ubicar al trabajador(a) en puestos de trabajo bajo condiciones inadecuadas a su capacidad física y mental; lo cual dificulta: la prevención de accidentes laborales, el controlar condiciones inseguras y enfermedades ocupacionales. No se encontró en la literatura médica/ergonómica venezolana un cuerpo de doctrina sobre la evaluación de la aptitud física para el trabajo: capacidad aeróbica, índice de masa corporal, frecuencia cardíaca en reposo, presión sanguínea. Objetivo: presentar una propuesta metodológica para evaluar la aptitud física para el trabajo. Paradigma: cuantitativo, metodología: diseño bibliográfico, tipo de investigación: documental secundario, nivel: explicativo/proyectivo, modalidad: proyecto especial, que atiende necesidades específicas para obtener/interpretar valores idóneos. Resultados: un protocolo para colectar data antropométrica/fisiológica, la cual constituye una novedad que contribuye a evaluar ergonómicamente la aptitud física de la población laboral venezolana, es un recurso pedagógico útil como manual de instrucciones.

Palabras clave: Protocolo; Aptitud Física; Trabajo; Evaluación de Capacidad de Trabajo; Mediciones.

INTRODUCTION

As of the date of the present work, in Venezuela, workers are frequently placed in jobs under conditions that are not adequate for their physical and mental capacity. For its correction, among other legal instruments, there is the Organic Law of Prevention, Conditions and Work Environment, which directly addresses the issue in Article 56, Paragraph 1. The poor location of the worker contributes to hindering the prevention of occupational

accidents and the control of unsafe conditions and occupational diseases, according to the law above in Article 62, Paragraph 3.[1]

The occupational physician [or the ergonomist], due to his specialized knowledge of the interaction between work and the person, is the ideal professional to determine whether or not a specific job requires the evaluation of the psychophysical capacities of the worker, as well as to define what are precisely those capacities without which the worker could not carry out the essential functions of that job and with what criteria they should be evaluated.

The application of the guidelines above to evaluate the psychophysical capabilities of a worker prior to hiring is essentially intended to rule out causes of exclusion for a particular job, and medical certification, in this sense, is not a specific function of occupational medicine but can be performed by any medical professional [o ergonomists] with the required competence according to the case.[2]

It was found in the Venezuelan medical/ergonomic literature prior to the present research studies that, in greater or lesser detail, address the evaluation of physical fitness (or physical condition) for work, among them: Prediction of Anthropometric Dimensions in Bipedestation and Physical Fitness in Venezuelan Industrial Direct Labor Workers (MODIV), Regression Functions Predictors of Muscular Fitness in Venezuelan Manual Workers: A Pilot Test, Prediction of Anthropometric Dimensions and Aerobic Capacity in Venezuelan Industrial Direct Labor Workers, Applicable to Ergonomic Design and Evaluation of Motor Fitness of the Members of the Soccer School of the Pedagogical Institute of Caracas.[3,4,5,6]

There are publications on the evaluation of physical fitness for work in countries such as Colombia,[7] the United States of America, and Australia.[8,9] In that sense, it can be referred that the protocols in physical fitness are applied in military institutions in the USA of which minimum requirements such as height, weight and the ability to perform a battery of exercises such as two minutes of push-ups, two minutes of sit-ups and a timed run for three kilometres. From this battery, points are added depending on the age and Sex and from there, the necessary points to be able to enter. However, it is essential to note that in the case of the world of work is not intended to exclude but to preserve health and safety.[10]

Taking into account the previous assumption, for any professional occupation, it is necessary to have an optimal level of physical aptitude and possible to evaluate it through its four components (cardiorespiratory resistance, muscular aptitude, flexibility and body composition); additionally, at the employer's discretion, the following can be considered among others: blood pressure, heart rate at rest, body mass index.[7]

Muscular fitness and aerobic capacity are critical threshold competencies when considering people eligible for specific jobs; however, to measure them, the field investigator must have a series of sophisticated equipment that allow the evaluation of the worker's physical capacity such as direct methods such as the use of the stress test that measures the maximum aerobic capacity or VOmax2 that require expensive equipment in acquisition and operation, indirect methods such as the step test or USDA Forest Service Step Test applied in researches such as Two alternatives for the study and promotion of the physical capacity of workers, on physical capacity.[11]

On the other hand, there are so-called exercise batteries or tests used for the practice of sport and health, but they are also associated with anthropometry. There are three references associated with the field of physical activity and health: the Eurofit battery for adults (Oja, Tuxworth, 1995), intended for adults of working age between 18 and 65 years of age, using three tests that prioritize the dimensions of physical fitness. The Canadian Physical Activity Fitness and Lifestyle Appraisal (CPAFLA) battery (1996), designed to assess the physical fitness of the general population, and the health-related Fitness Test Battery Adults (1996), designed to promote the practice of middle-aged adults.[12]

For the specific case of this research, the following works will be taken as reference: Regression Functions Predictors of Muscular Fitness in Venezuelan Manual Workers: A Pilot Test and Prediction Of Anthropometric Dimensions In Standing and Physical Fitness In Venezuelan Direct Industrial Labor Workers (MODIV), which used an exercise battery for direct labour workers, consisting of three tests that allowed measuring physical fitness and endurance for work: Push-ups or push-ups, sit-ups and sit-up and stand-up.[3,4]

The general objective is to develop and present a methodological proposal to collect data to evaluate physical fitness for work in an objective, simple, reliable, fast and low economic impact way. This work is justified by its contribution to the correct placement of the worker in a work position that does not exceed his aerobic capacity or muscular capacity, which is in line with the conception of the work position that allows the development of a harmonious relationship between the worker and his work environment.[1]

METHODS

The components and criteria of the proposed tests are preliminary and of general purpose; they are not specific to the job for which the applicant is applying or for which the reintegrating worker is applying.

At the beginning of the first session, each of the participants them are asked to previously determine risks related to any disease that would not allow the application of the test and to sign an informed consent approved by the Occupational Health and Safety Committee of the company and to fill in a medical-occupational history on

their physical activity practised so far, medical history, level of training and level of physical activity performed on a daily basis.

With these last data obtained in the history, the subjective evaluation of the average physical condition of each participant is started. The assessment must be carried out according to the order indicated in this work, proceeding to the next stage only if the previous one has been passed.

If the applicant or worker does not obtain passing results in this preliminary triage of evaluation of the physical aptitude for work, he/she should not be incorporated into the work; it is up to the employer's judgment the conduct to follow an option if the case deserves it, is to continue with specialized studies.[13]

Intervention protocol and order of the physical aptitude tests

[14] These non-invasive tests were chosen because of their minimal equipment requirements and ease of administration.

The protocol consists of three stages: Stage A, which relates to the registration of the worker: Name Sex, age, smoker; measurements: blood pressure(S/D), HRrest, Relative Aerobic Capacity CAR (V02max), Absolute Aerobic Capacity (AAC) and Average Physical Work Capacity (APWCsubject). Stage B: BMI measurements, abdominal perimeter and Stage C: Physical fitness measurement: upper body: push-ups, mid-body: sit-ups and lower body: sit-ups/stand-ups.

Stage A: recording procedure, e.g., In this case, a female worker is taken as a referent for the recording of the protocol.

Sex
Male:__**Female:** _X_, **Age**: 46 years, **Smoker**: __ **Non-smoker**: _X_.
Blood pressure
Systolic: 105 mm Hg, **Diastolic:** 65 mm Hg).

A sphygmomanometer is used, which is a device to measure blood pressure indirectly; some of them, in addition to the systolic and diastolic pressures, indicate the heart rate. According to the American Heart Association and the American College of Cardiology,[15] see table 1, the values are recorded in the format used in table 6.

Table 1. Classification of Arterial Hypertension according to the AHA/AAC

Category	Blood pressure figures in mm/Hg
< 120 y < 80	Normal
120 a 129 y < 80	Elevated
130 a 139 u 80 a 89	Stage I
≥ 140 a 90	Stage II

Source: New American College of Cardiology/American Heart Association Hypertension guidelines for the treatment of hypertension.[15]

Resting Heart Rate (HRF)

The resting heart rate (HRF) is measured when the subject has been at rest for 5 to 10 minutes in a supine or sedentary position.

As alternatives to measure heart rate, a stethoscope can be used for auscultation; another is palpation with the scorekeeper's index and middle fingers of the hand over the radial artery, directly aligned with the base of the subject's thumb.[16] When taking the pulse to measure heart rate (HR), it should be kept in mind that the pressure on the fingers should be light to avoid occluding (obstructing) the blood flow.[17]

However, However, a heart rate <60 does not necessarily indicate a medical problem. It could be the result of taking a beta-blocker. A low heart rate is also standard for people who are very physically active or athletic. Moderate physical activity does not affect the resting pulse rate much. If you are fit, it may change to 40. A less active person might have a heart rate between 60 and 100. This is because the heart muscle has to work harder to maintain bodily functions, making it numerically higher.[16]

Table 2 presents the values of the resting heart rate indicated by the American Heart Association for the U.S. population[18]; taking the example of the worker being 46 years old, the value of the resting heart rate is 57 beats/min and on the basis of table 2, this worker is placed as Athlete. The record is taken to the table 6.

Table 2. Graph of resting heart rate

Resting heart rate chart for men							
Age	**Athlete**	**Excellent**	**Good**	**Above average**	**Average**	**Below average**	**Poor**
18-25	49-55	56-61	62-65	66-69	70-73	74-81	82+
26-35	49-54	55-61	62-65	66-70	71-74	75-81	82+
36-45	50-56	57-62	63-66	67-70	71-75	76-82	83+
46-55	50-57	58-63	64-67	68-71	72-76	77-83	84+
56-65	51-56	57-61	62-67	68-71	72-75	76-81	82+
65+	50-55	56-61	62-65	66-69	70-73	74-79	80+
Resting heart rate chart for women							
Age	**Athlete**	**Excellent**	**Good**	**Above average**	**Average**	**Below average**	**Poor**
18-25	56-60	61-65	66-69	70-73	74-78	79-84	85+
26-35	54-59	60-64	65-68	69-72	73-76	77-82	83+
36-45	54-59	60-64	65-69	70-73	74-78	79-84	85+
46-55	54-60	61-65	66-69	70-73	74-77	78-83	84+
56-65	54-59	60-64	65-68	69-73	74-77	78-83	84+
65+	54-59	60-64	65-68	69-72	73-76	77-84	84+

Source: American Heart Association.[17]

The maximum heart rate (HRmax or HRmax) should be measured directly; if it is not possible, you can take equation, which is reliable.[16,19,20]

HRmax = 205,8 - 0,685(Age).

Relative aerobic capacity (CAR or VO2max)

The CAR can be evaluated:

(a) Directly on laboratory equipment (a treadmill or a cycle ergometer) by measuring O2 consumption and the volume of expired CO2 air.[21]

b) Indirectly: using, among others, the USDA Forest Service step test.[14]

c) It can also be estimated without the need for physical exercise, using equation[1], which is that estimation that allows us to measure CAR without the use of sophisticated equipment using equations that predict that value.

In this sense, taking the example of the 46-year-old female worker, the methodology C was used. Let it be the case of a 46-year-old woman with a body weight of 58,9 kg and a resting heart rate of 57 beats/minute.

Estimate:

(a) your maximum heart rate (HRmax).

b) your relative aerobic capacity (CAR).

HRmax = 205,8 - 0,685(Age)
= 205,8 - 0,685(46)
= 174,29 beats/min.

For the calculation of CAR, equation (2) is used.[22]

CAR = VO2max = 15,3 x (HRmax/HRrest)
= 15,3 x (174,29/57)
= 46,78 ml O2/kg-min.

The hypothetical subject: 46-year-old female, 58,9kg, with 46,78 ml O2/kg-min, is in the Superior category based on the standards in table 3: Cardiorespiratory Fitness Classification. This record goes to table 6.

Table 3. Cardiorespiratory fitness classification: VO2 max (ml O2/kg-min)

Age (years)	Deficient	Moderate	Good	Excellent	Superior
Woman					
20-29	≤35	36-39	40-43	44-49	50+
30-39	≤33	34-36	37-40	41-45	46+
40-49	≤31	32-34	35-38	39-44	45+
50-59	≤28	29-30	31-34	35-39	40+
60-69	≤25	26-28	29-31	32-36	37+
70-79	≤23	24-26	27-29	30-36	37+
Man					
20-29	≤41	42-45	46-50	51-55	56+
30-39	≤40	41-43	44-47	48-53	54+
40-49	≤37	38-41	42-45	46-52	53+
50-59	≤34	35-37	38-42	43-49	50+
60-69	≤30	31-34	35-38	39-45	46+
70-79	≤27	28-30	31-35	36-41	42+

Source: Fitness Specialist Manual The Cooper Institute for Aerobics Research, Dallas, TX. (23)

Absolute aerobic capacity

Example: Taking into consideration the CAR = 46,78 mlO2/kg-min, estimate a) the corresponding absolute aerobic capacity (AAC) and b) the average physical work capacity (APWC) of the subject for a day of 8 hours (480 minutes).

In the case of the AAC, it can be calculated from the values of the CAR.[14,15] On the other hand, the amount of heat generated during physical exercise corresponds to a value of 5,03 kcal/litre of O2 consumed [24]

CAA = (CAR, mlO_2/kg-min.) X
(peso corporal) X (1litro/1000ml) X
(5,03 kcal/1litroO_2)
= Kcal/min.

CAA = (46,78 mlO_2/kg-min.) X (58,9kg) X (1litro/1000ml) X (5,03 kcal/1litro
= 13,85 Kcal/min.

Bink's Law is the standard for determining the time limits (minutes) and percentage of maximum metabolism to maintain low metabolite levels during labor, as shown in table 4 Time limits (minutes) and percentage of maximum metabolism.

Table 4. Bink's Law. Maximum Acceptable Load (AML) depending on time (Time limits (minutes) and percentage of maximum metabolism)

% Metabolism	100	90	80	70	60	50	40	35	30	20
t Limit (minutes)	5	10	20	40	80	160	320	480	640	1280

Source: Evaluation of dynamic workload. Pontificia Universidad Javeriana.[25]

Capacidad promedio de trabajo físico:

$(CPTF)_{sujeto}$ = 13,85 X 0,35
= 4,84Kcal/min.

Once the value is estimated, it is related according to activity levels: Light corresponds to a working metabolism of <1600 kcal/day (<3,33 kcal/min), a medium activity level corresponds to 1600-2000 kcal/day (3,33-4,16 kcal/min) and a heavy activity level of>2000 kcal/day (>4,16 kcal/min). [26]

It follows from the above that the subject is suitable for placement in a heavy activity position, as recorded in table 6.

Stage B: To estimate BMI, the subject's height and weight should be measured.

Height (mm) or stature (T) Procedure: The height or height is taken following the protocol or (body height), which is the vertical distance from the ground to the highest point of the head (vertex). The subject (barefoot) stands upright, fully erect and with feet together. The head is oriented according to the Frankfurt plane. Anthropometer/Tallimeter [27]

Example: 1,70 m (1700 mm).

Body mass (kg): the subject stands on a scale. Scale. Measurements are expressed in kg and tenths of kg.[28]

Example: 58,9kg

Body mass index (kg/m2)

Body mass index (BMI): mathematical ratio: weight, kg/ (height, m2)

Example: BMI = 58,9 kg/ (1,70)2 = 20,38, this value is placed according to table 5 and then placed in table 6.

Table 5. Classification of overweight and obesity according to BMI, waist circumference and associated disease risk*

	Risk of disease* in relation to normal Weight and waist circumference			
	IMC (kg/m^2)	Type of obesity	Men 102 cm Women 88 cm	Men >102 cm Women >88 cm
Underweight	18,5		-----	-----
Normal+	18,5 – 24,9		-----	-----
Overweight	25,0 – 29,9		Weight gain	High
Obese	30,0 – 34,9	I	High	Very High
	35,0 – 39,9	II	Very high	Very High
Extreme Obesity	40	III	Extremely high	Extremely high

***** Risk of type 2 diabetes, hypertension and CVD.
+ Increased waist circumference may also be a marker of increased risk even in people of normal weight.
Source: National Heart, Lung, and Blood Institute. Bethesda, MD, USA. [28].

Abdominal circumference (mm), Procedure:

For the perimeter, the trunk is taken measured at a height equidistant between the lower ribs and the highest iliac crest. The subject stands upright, completely erect, with the feet together and with the abdominal muscles relaxed. Tape measure [29] Example: BP = 0,77 m = 77 cm and recorded in table 6.

Stage C:

Physical fitness of the worker:

Once stages A and B have been completed, proceed to evaluate the physical fitness of the workers, after a 10-15 min rest. Measurements are taken of the parts of the body: upper, middle and lower body.

Upper body: The push-up test is used: the subject lies supine (face down) on a mat on the floor with legs together and hands under the shoulders, pointing them forward".[16]

The worker will do as many push-ups as he/she can without a time limit; the test is stopped when effort begins to be observed. The number of times it is registered and is verified with the references of The Canadian Physical Activity.[29]

The middle part of the body: It can be evaluated using the 1-minute test for the abdominals (Curl-Up). The equipment consists of a mat and a stopwatch. The subject lies on a mat on the floor in the supine position (face up) with the knees bent at an angle of 45 degrees, with the feet fully supported on the floor.[14,30]

The test is stopped after one minute or because the worker stops. Then, the number of times he/she stopped is recorded and compared with the reference parameters on abdominal tests for both men and women by age group.[31]

Lower body: requires simple equipment: a mat, a stopwatch, a folding chair or a 43-45 cm chair. In this procedure, the subject must stand up cro, hold his hands, sit down and stand up until the minute is completed or stop before the established lower body time.

Once the test is finished, it is recorded and evaluated according to the parameters.[31] Once the results are obtained, they are placed in Table 6, and the definitive evaluation and recommendations for that worker are made.

RESULTS

Once all the information has been compiled, their physical fitness is assessed in the observations box and this is compared with the initial records in terms of the habit of maintaining physical activity. Depending on

the results obtained and their physical condition, the worker may have a series of ecommendations to improve their physical condition and maintain their health values in the workplace.

Table 6. Classification of physical fitness for the job.

Name:			**Sex** M: F: X	Age :46 Smoker:	Non Smoker: X
STAGE A					
	1	2	3	4	5	Observation
Blood pressure						
• Systolic	105 Normal					
• Diastolic	65 Normal					
FCR	60' 57beats/min	60-70	71-80	81-100	›100	Observation Value: Athlete
CAR VO_{2max}		Def.	Moderate	Good	Excellent	Superior 46,78ml O2/kg-min.
CAA			13,85 Kcal/min.	Observation:		
$(CPTF)_{sujeto}$	Slight		Medium	Heavy 4,84Kcal/min		Observation
STAGE B						
IMC	Under	Standard 20,38	Sob. Weight	Ob 1 Ob2		Obext
Abdominal Perimeter	PA' 95 cm in women; Pa'100cm in Men: Risk 77 cm (No risk)					
STAGE C						
Physical fitness of the body						
N° Chest push-ups.	Reference parameter	N° Abdominals		Reference parameter	N° Rising/ Sitting	Reference parameter
11	Good	13		Average	18	Above average

Observations: The worker presents excellent physical conditions to be able to perform the task referred to her job. It is recommended to follow her physical activity and eating habits.
Abbreviations: 1: Normal blood pressure, 2: Prehypertension, 3: Prehypertension stage 1, 4: Hypertension stage 1, Prehypertension stage 2, Sob. Weight: overweight, Obesity 1, Obesity 2, Obsext: extreme obesity.

DISCUSSION

This study proposes a way to compile objective information on the anthropometric and physiological variables considered. Such documentation should enable the occupational physician/ergonomist to make better judgments than is possible from general summary statements.

Clinical implications

The scheme provided in this work allows us to corroborate that fitness for work decreases with increasing age; the same happens with aerobic capacity; overweight also negatively affects aerobic capacity; static postural balance capacity decreases with age and also by diseases/accidents that decrease the quality of the neuromuscular system.

The practical implication of this information in subject evaluation is that performance/fitness on timed tests is age-specific and that the expectations of the occupational physician/ergonomist for applicants and reentry workers should be based on the age of the subject.

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CONCLUSION

The information obtained by employing the proposed fitness-for-duty evaluation protocol is an instance, which allows the occupational physician/ergonomist to have a perspective on the performance/risk that should be expected of non-disabled persons.

It is the first publication in Venezuela that proposes a systematized evaluation that addresses critical components of the physical condition of each applicant or worker. In that sense, it serves as a referential framework for future evaluations and as a criterion to assess the progress of each subject.

It provides support in terms of structural organization, registration, and control of the workforce and activities carried out.

The evaluation and recording of physical capacities is a didactic resource that allows scientific control of the needs and changes that occur in the human organism of the workforce, which can be presented as an instruction manual.

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