DETERMINATION OF MAXIMUM ACCEPTABLE WORK TIME AND HEART RATE IN WORKERS OF FOOD MARKETS IN THE CITY OF LOS MOCHIS, SINALOA

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Abstract

I**ntroduction**: This study looks to determine how long a person can work without increasing their heart rate leading to abnormal cause of fatigue. The heart rate was measured with an electronic device that continuously records a person's heart rate and its variations during a workday. **Objectives**: To determine the relationship between relative heart rate and workers TMTA in food markets in Los Mochis Sinaloa. **Delimitation**: The study was conducted in food markets in the city of Los Mochis where workers carry out activities that require no effort and serve as a reference parameter to regulate working hours. **Methods**: A sample population of more than 30 workers and the data were statistically analyzed using a software (Statistica). Those who were eligible for screening were fitted with an electronic device (Polar FT60) to measure their resting heart rate, which was programmed to store data during the workday, after the device was removed and the information stored, the data was introduced into the software to make the corresponding analysis. **Results**: Of the variables analyzed, it was found that age affects Resting Heart Rate, Maximum Heart Rate, the TMTA, and relative heart rate, the means of transportation affects your maximum heart rate, the extra activity affects the maximum heart rate; Working days affect the maximum heart rate. Based on these results it was found that people aged 40-49 years worked nearly two hours longer than they should with respect to the data of TMTA. **Conclusions**: We suggest that persons aged 40-49 years with strategic breaks your heart rate is not altered and can pay more. Instead, people under 20 have a much higher

TMTA and could work longer hours without needing to rest, provided they do not violate relevant laws.

Key words: fatigue, heart rate, ergonomics, work capacity

Resumen

Introducción: Esta investigación buscó determinar el tiempo que una persona puede trabajar sin incrementar su Frecuencia cardiaca dando lugar a esfuerzos excesivos motivo de fatiga. La Frecuencia Cardiaca se midió con un dispositivo electrónico que registró de manera continua la FC de una persona y sus variaciones durante una jornada laboral. **Objetivos:** Determinar la relación entre la Frecuencia Cardiaca Relativa y el TMTA en trabajadores de mercados de abastos de Los Mochis Sinaloa. **Delimitación:** La investigación se llevó a cabo en los mercados de abastos de la ciudad de Los Mochis donde los trabajadores realizan actividades que requieren esfuerzos y no hay ningún parámetro que sirva de referencia para regular las jornadas laborales. **Metodología:** Se tomó una muestra poblacional de más de 30 trabajadores y los datos se analizaron estadísticamente por medio de un software (statistica). Los que resultaron aptos de la preselección se les colocó un dispositivo electrónico (Polar FT60) para medir su Frecuencia Cardiaca en Reposo, posteriormente se programo para almacenar los datos durante la jornada laboral, al término se retiró el dispositivo y se almacenó la información. Una vez recabados los datos se introdujeron al software para hacer el análisis correspondiente. **Resultados:** De las variables analizadas se encontró que la edad afecta la Frecuencia Cardiaca en Reposo, la Frecuencia Cardiaca Máxima, el TMTA y la Frecuencia Cardiaca Relativa; el medio de transporte afecta su Frecuencia Cardiaca Máxima; la Actividad Extra afecta la Frecuencia Cardiaca Máxima; y la Jornada laboral afecta la Frecuencia Cardiaca Máxima. En base a estos resultados se encontró que las personas de 40-49 años trabajaban casi dos horas más de las que deberían con respecto a los datos del TMTA. **Conclusiones:** Podemos sugerir que las personas de 40-49 años tengan descansos estratégicos para que su Frecuencia Cardiaca no se altere y puedan rendir mas, por el contrario las personas menores de 20 años tienen un TMTA mucho más alto y pudieran trabajar más horas sin necesitad de descansar.

Palabras clave: Fatiga, frecuencia cardiaca, ergonomía, capacidad de trabajo

I. **INTRODUCTION**.

Work is a source of psychological and social well-being of value to humans, and it provides most of the meaning and structure of our life. However, it can also cause adverse effects such as tiredness, stress, injury, DTA's, accidents, fatigue, and many others. We should consider the importance of an individual to develop their business activities in an environment where the employee makes the most physical and mental capabilities possible, therefore resulting in higher productivity, fewer accidents and greater satisfaction for the staff.

One way to measure the physical capacity of a Yorker is by monitoring their heart rate, which reflects the momentary physical state of the individual. We can then compare that with the parameters that can be obtained at rest and when performing a physical activity (FCR).

In recent times, devices have emerged that allow continuous heart rate recordings with no difficulty. The proposed system for the analysis of heart rate is more focused on sports medicine and not to the work environment. On this occasion we will use these devices for research that will carry out.

This research aims to keep track of the heart rates of people who work in food markets, with a heavy workload and long hours in the city of Los Mochis, Sinaloa and determine the TMTA (maximum acceptable work time) in order to present a history that serves food for thought for those who perform these tasks.

II. OBJECTIVES.

2.1 GENERAL OBJECTIVE

To determine the relationship between physical load, expressed as relative heart rate (FCR) and the maximum acceptable work time (TMTA) on workers in food markets in the city of Los Mochis, Sinaloa.

2.2 SPECIFIC OBJECTIVES

• Determine heart rate of workers at food markets in the city of Los Mochis, Sin.
• Determine the maximum acceptable work time (TMTA) to establish working days to help maintain a normal heart rhythm.

• Use the results to establish breaks at strategic times during working hours, thereby increasing worker productivity and prevent injuries or accidents.

III. MATERIALS AND METHODS.

3.1 METHODOLOGY

To obtain valid results it is necessary to use the appropriate methodology, the following will show how it will be carried out and how they will conduct the study to achieve the desired objective.

3.2 SUBJECT

The results of this research will be analyzed statistically. A sample population of more than 30 workers in one of the existing supermarkets in the city of Los Mochis (According to John E. Freund and Richard Manning Smith in his book "Statistics (1989)" he mentions that "You can not say exactly how large “n” should be so that you can apply the central limit theorem, but unless the distribution of the population has an unusual shape, n = 30 is usually considered large enough ") $N \geq 30$ approaches the normal distribution , making it statistically valid to use the mean and standard deviation of the sample. After selecting the appropriate population to determine the heart rate of workers using the Polar FT60 which will give us the results and changes in heart rate during a worker's workday.

3.3 Methods

1. Workers were pre-selected to conduct the investigation and were told about the importance of their cooperation in conducting the study in order to obtain real and reliable results

2. Explain to the employee the purpose of research and measurements to be performed and the methodology to follow, to subsequently sign the acceptance letter which confirms his permission to conduct this study.

3. Apply the survey to particular habits and physical condition.

4. Determine if the employee is eligible for the study, ie, has good health, does not suffer any chronic illness.

5. After determined that the worker is fit for study, proceed to place the polar and data transfer band.

6. We take the resting heart rate, that is, left undisturbed for 10 minutes than a worker, in the last 3 minutes, takes the heart rate, which will be recorded in the Polar FT60

7. Having set your heart rate at rest, the set the polar to "Start", to begin to measure heart rate of the worker and place your normal working hours for data collection.

8. At the end of the day reflected on, the polar sends the data to computer for later analysis.

9. We focus on the information collected through the survey and monitor Polar FT60 heart rate of total subjects

10. Once you have data from all individuals that are analyzed, use the Statistica program to determine the influence of variables on the TMTA on workers.

11. We get results, we can suggest some actions that would be of benefit to the participants.

12. Writing the final report which presents the final results and conclusions.

IV. RESULTS.

This section is referred to the results obtained during the investigation, which shows all the variables that were examined. They have some degree of impact on the dependent variables, which in this case are Resting Heart Rate, Heart Rate Relative, Heart Rate Maximum, and maximum acceptable work time. To facilitate the analysis they are grouped by age classes, and are as mentioned below.

1. <20 years
2. 20-29 years
3. 30-39 years
4. 40-49 years or more

With regard to means of transportation used by workers was the next group.

1. Public Transport.
2. Car.
3. Bicycle.
4. Motorcycle.

To identify whether workers perform some extra activity outside of work in which they were monitored. The following list took place.

1. Study
2. Work
3. No
4. Study and work

In relation to working hours the following classification.

1. 6-7 hrs.
2. 8-9 hrs.
3. 10-11 or more.

4.1 Age-FC Rest

Here are the results obtained by analysis of variance for data Resting heart rate taken from the study variables, taking into account that for all cases in this study, a α = 0.05.The analysis was performed with analysis of variance study, which was carried out using the computer program "Statistics". Each of the independent variables were analyzed individually with each of the dependent variables.

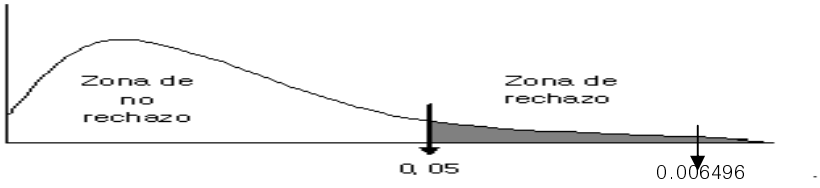
Table 1. Analysis of variance for data Resting heart rate depending on age.

Summary of all Effects; design: (tmta oficial..sta)

Continue... 1-EDAD

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3	449,8419	29	90,08114	4,993742	,006496

Table 2. F distribution for data Resting Heart Rate by the ages



As you can see from the graph the probability level (p level) of 0.006496 is within the area of rejection, and can say that the hypothesis that the means of the variances are equal and is rejected. So here, it is statistically proven that there is a significant difference in Resting Heart Rate Average in age classes that were analyzed. Therefore the Duncan Multiple Intervals test is performed to find the differences between ages.

Resting Heart Rate does affect workers differently depending on their ages.

Table 3. Duncan's multiple range data Resting heart rate depending on age

Duncan test; FC_REPO (tmta oficial..sta)

GENERAL MANOVA

Probabilities for Post Hoc Tests
MAIN EFFECT: EDAD

EDAD		{1} 93,00000	{2} 71,10000	{3} 82,46154	{4} 70,44444
1	{1}		,010028	,177172	,009850
2	{2}	,010028		,146720	,932100
3	{3}	,177172	,146720		,146331
4	{4}	,009850	,932100	,146331	

In making the comparison of means by the method of Duncan multiple interval, Table 2 shows that group 1 (93.00000) is the most affected in Resting Heart Rate, then there is group 3 (82.46154), a little less severely affected. We found that in groups 2 (71.10000) and 4 (70.44444) that younger people have a resting heart rate higher than other groups. We formed the following blocks.

{4} 70.44444

{2} 71.10000 — Block 1

{3} 83.83334

{1} 93.00000 — Block 2

Based on the results, two blocks can be formed. Block 1 composed of people of 20-49 years which have a resting heart rate lower (75 531 ppm) compared with those aged under 20 years, which have a resting heart rate higher (93 ppm).

Age – CF Maximum

For this analysis we took into account the classification of the ages mentioned at the beginning of this section

Table 4. Analysis of variance of the maximum heart rate data by age.

Summary of all Effects; design: (tmta oficial..sta)

Continue... 1-EDAD

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3	766,1447	29	9,301650	82,36653	,000000

Table 5. Duncan's multiple range for maximum heart rate data at different ages

Duncan test; FC_MAX (tmta oficial..sta)

GENERAL MANOVA

Probabilities for Post Hoc Tests
MAIN EFFECT: EDAD

EDAD		{1} 202,0000	{2} 196,5000	{3} 185,1538	{4} 175,7778
1	{1}		,032530	,000062	,000054
2	{2}	,032530		,000202	,000062
3	{3}	,000062	,000202		,000752
4	{4}	,000054	,000062	,000752	

{4} 175.7778

{3} 184.9167

{2} 196.5000

{1} 202.0000

In making the comparison of means by Duncan's multiple interval, we can see that all means are different as different age affects the maximum heart rate of people, however, we can say that the level of involvement increases as age decreases, i.e. those under 20 have a maximum heart rate higher than others.

4.3Relative Age- CF

Table 6. Analysis of variance for relative heart rate data by age.

Summary of all Effects; design: (tmta oficial..sta)

Continue... 1-EDAD

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3	,015166	29	,004620	3,282351	,034821

Table 7. Duncan's multiple interval for the relative heart rate data at different ages

Duncan test; FC_RELAT (tmta oficial..sta)

GENERAL MANOVA

Probabilities for Post Hoc Tests
MAIN EFFECT: EDAD

EDAD		{1} ,0366972	{2} ,1595019	{3} ,1083887	{4} ,1850394
1	{1}		,040536	,199187	,017189
2	{2}	,040536		,356631	,643301
3	{3}	,199187	,356631		,194769
4	{4}	,017189	,643301	,194769	

.

{1} .0366972 } Block 1

{3} .1083887 }

{2} .1595019 } Block 2

{4} .1850394

Taking into account Duncan's Multiple Intervals, we can form two blocks because there is no significant difference between means of groups 2, 3 and 4 (Block 2), but between the mentioned groups and group 1 (Block 1). We can conclude that people of 20-49 years have the same effect on the relative heart rate, i.e. no significant difference between the relative heart rate. It should be mentioned that the people of Block 1, being the youngest, they have a relative heart rate lower than those of block 2, that is the people of 20-49 years.

4.4 Age - TMTA

This comparison takes into account the grouping of ages into classes as mentioned at the beginning of the paragraph, the maximum acceptable work time is obtained by applying the formula mentioned in the theoretical framework.

Table 8. Analysis of variance for TMTA data by age.

Summary of all Effects; design: (tmta oficial..sta)

Continue... 1-EDAD

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3	146493,5	29	34660,08	4,226577	,013512

Table 9. Duncan's multiple range data TMTA depending on age.

Duncan test; TMTA (tmta oficial..sta)

GENERAL MANOVA

Probabilities for Post Hoc Tests
MAIN EFFECT: EDAD

EDAD		{1} 904,2840	{2} 480,0739	{3} 636,0993	{4} 410,2464
1	{1}		,010923	,083216	,004292
2	{2}	,010923		,305094	,643854
3	{3}	,083216	,305094		,163597
4	{4}	,004292	,643854	,163597	

{4} 410.2464
{2} 480.0739 } Block 1

{3} 647.3143

{1} 904.2840 } Block 2

Based on these results we can say that in groups 2, 3 and 4, the mean difference was not significant so they can form a block (Block 1), age affects the same way on TMTA, however, group 1 compared with the other groups had significant difference so it will form another block (Block 2) In conclusion, people between 20-49 years are those with a lower TMTA (8.7303 hours on average) and people aged under 20 increased TMTA (15.0714001 hours on average)

4.5 Transportation – Max CF

Table 10. Analysis of variance of the maximum heart rate data as transport.

Summary of all Effects; design: (tmta oficial..sta)

Continue... 1-TRANSPOR

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3	252,0229	29	62,48666	4,033227	,016336

Table 11. Duncan's multiple interval for maximum heart rate data as transport.

Duncan test; FC_MAX (tmta oficial..sta)

GENERAL MANOVA
Probabilities for Post Hoc Tests
MAIN EFFECT: TRANSPOR

TRANSPOR		{1} 194,1250	{2} 183,1905	{3} 192,0000	{4} 186,0000
1	{1}		,108271	,728200	,215129
2	{2}	,108271		,179534	,646119
3	{3}	,728200	,179534		,329871
4	{4}	,215129	,646119	,329871	

{2} 183.1905

{4} 186.0000

{3} 192.0000

{1} 194.1250

In this analysis we do not form blocks because there is no significant difference between the means of the data from these means of transport, ie, maximum heart rate is the same alteration in a person being transported by bicycle to another who moves in any of the before mentioned transportation.

4.6 Extra activities- Max CF.

This analysis considers Extra Activity, those activities that people perform after completing their workday.

Table 12. Analysis of variance of the maximum heart rate data according to the extra activity.

Summary of all Effects; design: (tmta oficial..sta)

Continue... 1-ACT_EXTR

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3	553,8144	29	31,26685	17,71251	,000001

Table 13. Duncan's multiple interval for maximum heart rate data according to the extra activity.

Duncan test; FC_MAX (tmta oficial..sta)

GENERAL
MANOVA

Probabilities for Post Hoc Tests
MAIN EFFECT: ACT_EXTR

ACT_EXTR		{1} 198,3750	{2} 181,5000	{3} 182,2727	{4} 196,0000
1	{1}		,004340	,005162	,645708
2	{2}	,004340		,880958	,010972
3	{3}	,005162	,880958		,011971
4	{4}	,645708	,010972	,011971	

{2} 181.5000
{3} 182.2727
} Block 1

{4} 196.0000
{1} 198.3750
} Block 2

According to Duncan Multiple intervals can be two blocks because there is no significant difference between means of groups 2 and 3 (Block 1) and the means of groups 4 and 1 (Block 2). In conclusion, people who do not work (3) and those who work (2) have the same involvement on the maximal heart rate and people who study (1) and those who study and work (other than the described work) (4) have the same involvement of Maximum Heart Rate. It is worth mentioning that people who work well studied (1) and those who study and work (4) elsewhere have a higher maximum heart rate (182.2083 ppm on average) than those not working (3) and those that only work (2) (198.1111 ppm on average).

4.7 Working hours – max CF

Table 14. Analysis of variance of the maximum heart rate data according to the workday.

Summary of all Effects; design: (tmta oficial..sta)

Continue... 1-JOR_LAB

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2	238,6367	30	69,69695	3,423920	,045776

Table 15. Duncan's multiple interval for maximum heart rate data according to the workday.

Duncan test; FC_MAX (tmta oficial..sta)

GENERAL MANOVA		Probabilities for Post Hoc Tests MAIN EFFECT: JOR_LAB		
JOR_LAB		{1} 184,2667	{2} 183,6250	{3} 192,3000
1	{1}		,862905	,037177
2	{2}	,862905		,032173
3	{3}	,037177	,032173	

{2} 183.6350 } Block 1
{1} 184.2667 }
{3} 192.3000 } Block 2

In relation to the results of Duncan Multiple intervals no significant difference between groups 1 and 2 which form in Block 1 but no difference between the means of these groups and mean group 3 which is Block 2 In conclusion, those working between 6-9 hours daily have a lower maximum heart rate (184.0478 ppm) than people who work 10 hours or more per day (192.3 ppm)

4.8 COMPARISON OF TMTA

One of the objectives of the research is to determine the TMTA in order to know whether people are working harder than your body can endure without reaching the heart rate above the maximum levels already mentioned. That is why the following is a table that reflects the average age TMTA rated compared with the hours they work, which was obtained from the records that showed the heart rate monitor Polar FT60 while the workers performed their tasks.

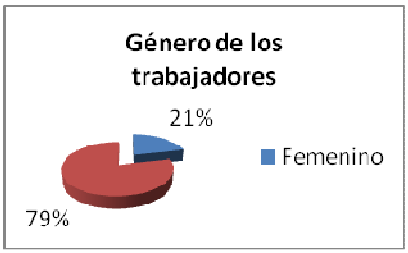
Table 16. Comparison TMTA

	AVERAGE TMTA (HRS)	AVERAGE JOR REAL (HRS)
TMTA 1 (less tan 20 yrs.)	15,07	10:55:02
TMTA 2 (de 20-29 yrs.)	8,00	8:44:52
TMTA 3 (de 30-39 yrs.)	10,60	8:42:41
TMTA 4 (de 40-49 yrs.)	6,84	8:09:34

Looking at the table, there is a big difference between the time that people in these age ranges may labor without their heart rate being significantly affected.

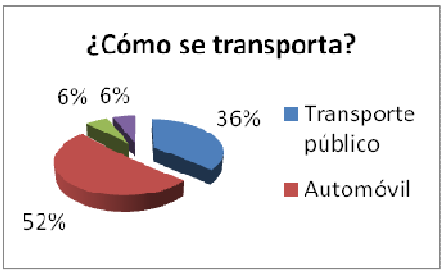
4.9 DESCRIPTIVE STATISTICS

Figure 1. Gender statistics of those who were under study.



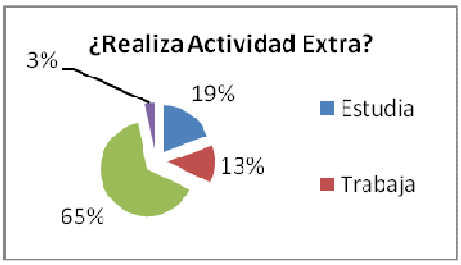
21% of people who underwent this study are women and 79% are men.

Figure 2. Statistical means of transport used by workers.



30% use public transport, 42% travel by car, bike 5%, 3% by motorcycle and 18% by walking.

Figure 3. Statistics extra activities performed by workers.



19% study, 13% work in another job, 65% have no activity, 3% study and work apart from the work that was done from the research.

Figure 4. Statistics of hours working per day.

The 40% work 6-7 hours daily, 16% of 8-9 hours and 44% of 10-11 hours or more.

V. CONCLUSIONS AND RECOMMENDATIONS.

Under the results of this research we can make some recommendations mentioned below

- . It is true that people aged 40-49 years had an average of 6.84 hrs TMTA

Table17.TMTA comparison

	AVERAGE TMTA (HRS)	AVERAGE REAL (HRS)
TMTA 1 (LESS THAN 20 yrs. old)	15,07	10:55:02

TMTA 2 (de 20-29 yrs.)	8,00	8:44:52
TMTA 3 (de 30-39 yrs)	10,60	8:42:41
TMTA 4 (de 40-49 yrs)	6,84	8:09:34

Table 18. Comparative table betwen real and TMTA

AGE	N	AVERAGE TMTA (hrs)	AVERAGE REAL TIME WORK (hrs)	TIME EXCEEDED ON AVERAGE	% OF POPULATION
Less than 20 yrs.	1	15.07	10:55:02	0	3.03 %
20-29 yrs	10	8	8:44:52	44 min	30.30 %
30-39 yrs	13	10.6	8:42:41	0	39.39 %
40-49 yrs	9	6.84	8:09:34	1:19 hrs	27.27 %

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