Le jeûne du Ramadan affecte-t-il la charge physique de travail?

Does Ramadan fasting affect the physical workload?

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RÉSUMÉ

Objectif: Quantifier la charge physique de travail pendant le mois du Ramadan 2015 (survenant en été) et vérifier si cette charge change de manière significative par rapport à la période de non-jeûne (en été ou en hiver).

Méthodes: Il s'agissait d'une étude cohorte prospective conduite pendant 18 mois et comportant trois visites : (V1): le mois de Ramadan à la saison chaude, (V2): la saison chaude en dehors du Ramadan et (V3): la saison froide en dehors du Ramadan. L'étude a
été menée dans deux entreprises: une briqueterie et une entreprise de textile situées dans le gouvernorat de Monastir (Tunisie). La population a comporté 12 hommes de chaque entreprise, appariés selon l'âge. L'étude a inclut un questionnaire et des enregistrements de la fréquence cardiaque conformément aux recommandations du niveau d'analyse de l'organisation internationale de standardisation8996 permettant l'évaluation de la charge physique de travail.

Résultats: Durant le Ramadan, la charge physique de travail était «Moyenne» sans différence significative des valeurs moyenne ±écart type du métabolisme équivalent entre les deux groupes de travailleurs (287,00±70,5 W contre 224,21±43,01W, respectivement dans la briqueterie et l'entreprise de confection). Le métabolisme de travail et le pourcentage d'utilisation de la capacité maximale de travail ont diminué en V2 et V3, sans différence significative entre les deux entreprises et les trois visites.

Conclusion: Cette étude a objectivé une charge physique de travail moyenne mesurée au cours du mois de Ramadan dans deux secteurs différents et ne variant pas en dehors du Ramadan.

Mots-clés

Religion, alimentation, charge physique de travail, métabolisme équivalent, contrainte thermique.

SUMMARY

Aim: To quantify the physical workload during the Ramadan 2015 (summer season) and to verify if this load changes significantly compared with periods of non-fasting (in summer or winter seasons).

Methods: It was an18-month prospective cohort study conducted in a brickyard and a textile manufacturing company located in the governorate of Monastir (Tunisia). It was based on the results of three visits: The first one (V1) was carried out in the month of Ramadan in the hot season, the second visit (V2) took place in the hot season outside of Ramadan and the third one (V3) was in the cold season outside of Ramadan. During these visits twelve male workers from each company matched by age filled out a questionnaire and went through a heart rate recording according to the recommendations of the analysis level of the International Organization for Standardization 8996 enabling the evaluation of the physical workload.

Results: During Ramadan, the physical workload was rated as «Medium» without any significant difference between the equivalent metabolic rate means ± SD of the two groups (287.00±70.5 and 224.21±43.01W respectively in the brickyard and in the textile manufacturing company). The working metabolic rate and the percentage of use of the maximum working capacity decreased in V2 and in V3 with no significant difference between the two companies and the three measurement visits.

Conclusion: The physical workload in the month of Ramadan measured in two different activity sectors was found to be «Medium» and did not significantly differ from that noted in the non-fasting periods (outside of Ramadan).

Key-words

Religion, diet, physical workload, equivalent metabolic rate, thermal strain

INTRODUCTION

Ramadan fasting (RF) is one of the five pillars of Islam and is observed by millions of Muslims all over the world (1). RF comprises diurnal intermittent fasting where believers voluntarily refrain from eating and drinking from dawn to sunset (1,2).Since the Islamic calendar is based on the lunar year, which is about 11 days shorter than a solar year, Ramadan occurs

11 days earlier every year and happens during a different season every nine years (2). This, in turn, affects the duration of daytime and hence fasting duration which is much longer in summer than in winter (2-4). The period of fasting also varies depending on the geographical location of the country and can be as long as 18 hours/day in the summer of temperate regions (2,5). The effects of the daily fast are strongly influenced by climatic conditions being more severe in the summer than at other times **of** the year (2,5,6).

In Muslim countries, and during RF, work schedules are modified and working hours are drastically shortened mainly for **arduous** physical activities (5). This suggests that RF impacts significantly the physical work capacity of the subjects, increases the effort required to perform a given task, impairs physical performance, efficiency and endurance (5). In fact, many studies suggested that RF is likely to affect daytime activities and performance in the mental, physical and social domains (7-10). To the best of the author's knowledge, the rare Tunisian studies evaluating the physical workload during Ramadan were conducted in the cold season (11).

The aim of this study was to quantify **the physical load during the Ramadan 2015 (summer season)** and to verify if this workload changes significantly compared with periods of non-fasting (in summer or winter seasons).

POPULATIONAND METHODS

Study design

This was an18-month prospective cohort study conducted in two companies (a brickyard and textile manufacturing company) located in the governorate of Monastir (Tunisia). The current study included three visits:

- (V1):carried out in the month of Ramadan in the hot season (from June 17 to July 16, 2015),
- (V2):took place in the period of hot season outside of Ramadan (from August to September 2015)
- (V3):was in the period of cold season(from February to March 2016).

The study was approved by the research ethics committee of The **University**

Hospital Taher Sfar Mahdia (Tunisia) and all participants gave informed consent for the research and their anonymity was preserved.

Population

Twelve male workers from each company took part in the study. They were matched by age and randomly selected on basis of a nominative list provided by the **human resources department of each company.**

Two groups were defined:

-Group 1: workers in the brickyard company

-Group 2: workers in the textile manufacturing company assigned to the cutting workstation.

The survey was preceded by an individual interview with each subject to explain the study objectives, its practical progress, to guarantee anonymity and get informed consent. The criteria for non inclusion were as follows: refusal to participate in the study, non-fasting in Ramadan, a chronic pathology or a treatment affecting the heart function and being assigned to another workstation (other than the cutting station) for the textile manufacturing company

Data collection

During the survey, data related to general characteristics were **collected** :age (years), weight (kg), height(m), morphology, job tenure (years), characteristics of the workstation.

Morphology was **assessed** by the user taking into account the body mass index (BMI), the ideal weight, the lean body weight and the normal weight. The Morphology varies between 1 and 3 (gracile=1, normal=2, large=3)**(**12).

Recording of heart rate (HR)

HR recordings were performed according to the recommendations of the analysis level (3rd level/4) of the International Organization for Standardization (ISO) 8996 " Ergonomics of the thermal environment -- Determination of metabolic rate" (13). Polar HR monitors (Cardio Running RS400 and S610i)were used with discontinuous recording every 15 seconds, using transmitters and receivers.

The "HR data Interpretation" program (12) enabled the entry of HR values exceeding 99% of the time (HR 99), mean HR and the HR exceeding 1% of the time, the

duration of recording and the plotting of the curve of the variation of HR according to time. The duration of recording corresponded to the effective working hours and was evaluated before the start of the survey through open observation days. Recordings or parts of recordings affected by interference greater than 50% of their duration (reflected by a HR> 150 or <50 bpm) were eliminated. The program enabled to calculate successively (12):

• *The individual parameters:*
- BMI: Weight / Height²(12).
- Ideal weight estimated according to Creff's expression:0.9 x (Height- Age / 10 -100)**(**kg**)**(14)**.**
- Lean weight estimated according to the expression of Janmahasatian**et al. (15):**9270 x real weight / (6680 + 216 x BMI)(kg).
- "Normal" BMI **(BMIn)** = 22 + 0.23 x Age - Age² / 500(kg/m²) (12).
- Normal weight deduced from this "normal" BMI: BMIn x height² (kg) (12).

• *Metabolism of work parameters:*
- Maximum working capacity (MWC) = (18.0 - 0.1 x Age) x Weight (Watts (W)) (12,13).
- Maximum HR (HR max)= 208- (0.7 x Age) (bpm) (12,16).
- Equivalent metabolic rate (Meq) = a x HRm + b; where the slope a = (MWC - M0) / (HR max - HR 99) and the intersection b = M0 - a x HR 99; HRm: mean HR; M0: Metabolic rate corresponding to the HR99 (W)(%) (12).
- Percentage of use of the maximum working capacity (P%) = 100 x Meq / MWC.

Measurement of health parameters

Health parameters were collected before the start and after the end of each recording. They included the measurement of the HR at rest (bpm) and systolic and diastolic blood **pressures** (BP, mmHg) at rest.

4. Data analysis

The analysis was based on the metabolism of work measured during the working day, expressed either in absolute or relative values (tables 1 and 2). The workload was described as «Heavy», «**Medium**» or «Light» (12,17,18):

Table 1: Sociodemographic characteristics of the study groups (n=24).

Characteristics	Brickyard company (n=12)	Textile manufacturing company (n=12)	p
Age (years, mean± SD [minimum-maximum])	39.25±7.2 [29-57]	33.90±14.30 [19-58]	0.17
Groups: n(%) · Men≥ 45 years:	2 (16.6%)	3 (25%)	0.564
Job tenure (years, mean± SD [minimum-maximum])	12.80±6.30 [5-22]	4.10± 3.40 [1-12]	0.004
BMI (kg/m^2 mean± SD [minimum-maximum])	25.76±3.96 [23,66-27.87]	24.77±2.29 [23.26-26.19]	0.602
Obesity status: · Normal · Overweight	5 (41.6%) 5 (41.6%) 2 (16.6%)	5 (41.6%) 6 (50%) 1 (8.3%)	0.609

Box 1: interpretation of workload depending on Maximum working capacity (MWC) expressed in absolute values (W)

100% MWC	5 min	5kW			
			Heavy	8h	400 W
33% MWC	8h	330 W			
			Medium	8h	290 W
			Light	8h	170 W
	Rest	100 W			

Box 2: interpretation of workload depending on percentage of use of the maximum working capacity (Wp%MWC) expressed in relative values (%)

	Light	Medium	Heavy	Very heavy
W p % MWC	20%	30%	40%	50%

Data entry and analyses were performed using the SPSS® version 21.0. **The Chi-2 Test was used to compare qualitative data (% men aged over 45 years, obesity status).**
Kruskal-Wallis test was used to compare the two groups.

Table 2: Interpretation of heart rate recordings

	V1			V2			V3			
Brickyard Textile manufacturing company	P	Brickyard	Textile manufacturing company	P	Brickyard	Textile manufacturing company	P			Variation V1, V2, V3 (p)
Mean HR (bpm)	90.25±13.56	79.67±12.26	0.114	94.64±12.35	85.11±12.15	0.010	91.36±9.61	83.73±11	0.133	0.323
Mean absolute heart cost (bpm)	21.12±9.32	13.44±4.90	0.074	19.36±7.68	17.22±5.65	0.603	19.63±3.93	17.90±4.85	0.519	0.260
Mean relative heart cost (%)	18.60±8.67	11.35±3.92	0.021	18.55±6.974	14.75±4.52	0.175	18.12±4.01	15.18±3.75	0.088	0.266
Mean equivalent metabolic rate (W)	287.00±70.50	224.21±43.01	0.074	302.81±66.20	255.86±51.50	0.131	296.18±50.97	256.27±41.74	0.088	0.227
Mean% of use of MWC (%)	28.07±8.06	22.22±3.74	0.072	27.29±5.68	24.85±3.69	0.412	27.29±3.81	25.29±3,19	0.300	0.480

V1: The month of Ramadan in the hot season, V2: Period of hot season outside Ramadan, V3: Period of cold season, HR: heart rate, MWC: Maximum Working Capacity.Data were expressed as means±SD. Comparison between the two companies: Kruskal-Wallis test. Comparison between the three visits: repeated measures analysis of variance

Repeated measure analyses were used to evaluate the modification of parameter's in the three visits (V1, V2 and V3). A p-value **<**0.05 was considered as statistically significant.

A simple linear regression analyses was performed to evaluate the relationship between the HR and the variation of the Meq. The R-squared goodness-of-fit measure was calculated to indicate the percentage of the variance in the dependent variable (HR) that the independent variable explain.

RESULTS

General characteristics of the study population

Table I presents the sociodemographic characteristics of workers in the brickyard and in the textile manufacturing company.

The two groups had similar mean ages and BMIs and included similar percentages of workers being overweight or obese. The two groups mean BMIs were in the normal range. In the brickyard, job tenure was significantly three times greater than that in the textile manufacturing company (0.004).

Evaluation of physical workload

After discarding uninterruptable records, 59 ones were retained (Figure 1). Table II summarizes the interpretation of HR records (mean absolute and relative heart costs, mean Meq, and Mean P%). The main conclusions to be drawn were: first the physical workload in Ramadan was «**Medium»** without any significant difference between the two groups and secondly, there was no significant difference of the working metabolic rate and the P% between the two groups and **between** the three visits **measurements**.

The three curves plotted in Figure 2 represent the variations in Meq rate according to the variations of the mean HR (mHR) in V1, V2 and V3. The three curves were **found to be superimposed.**

Health parameters before and after HR recordings

Table III compares the health parameters between the two groups at each visit and the changes in parameters between V1, V2 and V3. In V1, the systolic and diastolic BPs and HR were in the normal ranges. The resting HRs in the two groups were similar before and after recordings. V2 and V3 resting HR values were also similar to that of V1

Table 3 : Health parameters before and after HR recordings

BrickyardTextile manufacturing companyPBrickyard	V1		V2			V3			Variation V1, V2, V3 (p)
	Textile manufacturing company	P	Brickyard	Textile manufacturing company	P				
Mean HR before recordings (bpm)	77.33 ± 11	74.78±16.69	0.666	80.75 ±14.93	80.44 ± 10.99	0.862	78.37 ±9.00	68.71 ± 8.61	0.072	0.299
Systolic BP beforeHR recordings(mmHg)	120.5 ±26.0	123.3±15.0	0.386	126.6 ±14.1	125.0 ±10.0	0.972	125.0 ±10.6	131.4 ±18.4	0.281	0.311
Diastolic BP beforeHR recordings(mmHg)	75.5 ± 18.1	73.3±7.0	0.730	77.9 ± 11.9	73.3 ±12.5	0.345	78.7 ± 9.9	77.8 ±16.3	0.867	0.317
Mean HR after recordings (bpm)	83.66 ±12.08	77.00±17.97	0.258	88.66 ±16.28	79.77 ±14.10	0.247	77.87 ±8.67	69.57 ±9.50	0.152	0.166
Systolic BP afterHR recordings(mmHg)	122.7 ±20.1	121.6±10.6	0.931	129.1 ±18.1	130.5 ±14.6	0.345	136.0 ±23.6	127.1 ±12.6	0.536	0.060
Diastolic BP afterHR recordings(mmHg)	77.7 ± 17.8	70.0±7.0	0.436	79.1 ± 11.6	71.6±12.9	0.219	79.3 ± 9.0	73.5±13.1	0.336	0.678

V1: The month of Ramadan in the hot season, V2: Period of hot season outside Ramadan, V3: Period of cold season, HR: heart rate, BP: Blood Pressure, bpm: beats per minutes. Data were expressed as mean±SD. Comparison between the two companies: Kruskal-Wallis test. Comparison between the three visits: repeated measures analysis of variance

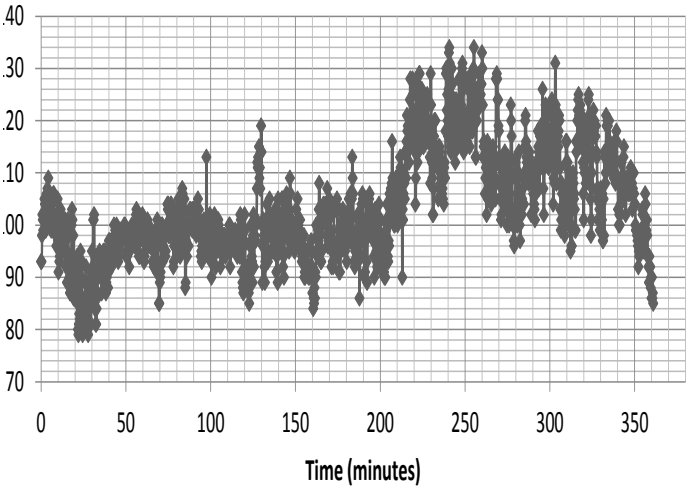
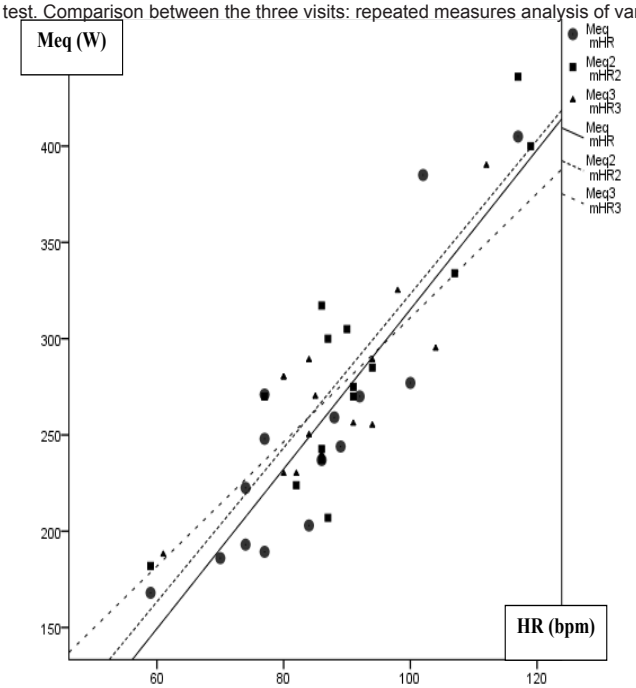


Figure 1 : Variation of the heart rate (HR) according to time.



HR: heart rate, mHR: mean HR, Meq: equivalent metabolic rate.
Meq: Equivalent metabolic rate in V1: mHR linear R2 = 0.780
Meq2: Equivalent metabolic rate in V2 : mHR2 linear R2 = 0.767
Meq3: Equivalent metabolic rate in V3: mHR3 linear R2 = 0.685
(V1): The month of Ramadan in the hot season
(V2): Period of hot season outside of Ramadan
(V3): Period of cold season

Figure 2 ; Variation of equivalent metabolic rate according to the mean heart rate at V1, V2 and V3

DISCUSSION

The results of this study showed that **the** physical workload in the studied companies during the holy month of Ramadan did not change significantly compared with that of non-fasting periods (in summer or winter seasons).

Many studies hypothesized that RF may impair daytime physical activities required for the performance of potentially hard work (7-10). A cohort prospective study was conducted following three visits to two companies aiming to quantify the physical **workload** load **during the Ramadan 2015 (summer season)**and to verify if this workload changed significantly compared with periods of non-fasting (in summer or in winter). The choice of companies was made according to their representativity in the central region of Tunisia and following complaints from the workers in both types of companies, especially those in the cutting workstation in the textile manufacturing company, about the arduousness of work in summer and especially in the month of Ramadan. This work was based on a questionnaire survey followed by **a** HR recording by cardiofrequencemeter. To the best of the authors' knowledge, this is the first Tunisian study having evaluated objectively the metabolism of work during Ramadan in summer.

The level of analysis of the ISO 8996 «Ergonomics of the thermal environment - Determination of energy metabolism» was used to evaluate the physical workload among these operators(13). This standard presents four levels of complexity and increasing measurement accuracy quality. In work situation, **the HR recording** during a representative period of the working day is the most accurate method available to evaluate the metabolic rate during work. Polar HR monitors, used in this study, are the most **widely** used in scientific studies because of their reliability (19). Their limitation is the interference that can occur near high-voltage lines, traffic lights, train catenaries, buses or trams, television sets, cars, computers, cardio equipment, mobile phones or security gates (19). Computers and wireless local area network (WLAN) terminals can also be a source of interference (19). During the recordings, the workers were asked to turn off their smart phones. In addition, and in order to limit this interference, the Polar RS400/S610i Cardio Running Receivers (watches) were placed at the belt of the transmitter. However, high-voltage lines, as well as WLAN terminals, exist in the environment of both companies mainly the textile manufacturing one. These interferences, when they exist, generate non-interpretable recordings, in whole or in part, explaining the 13 totally eliminated recordings, as well as the elimination of parts of the recordings.

To better evaluate the working metabolic rate, the two groups had similar mean ages and BMIs, since the estimation of the working metabolic rate depend on the BMI(12).In the brickyard company, job tenure was significantly three times greater than that in the textile manufacturing one. This significant difference was explained by the poor working conditions in the textile manufacturing company. Indeed, in this company, **compared with others active in the same sector in the region**, the workers reported a high thermal strain in summer and in winter and a desire to leave this company resulting in a significant turnover. Concerning the brickyard workers, they seem to be used to thermal constraints. Moreover, the administration authorized a work stoppage during RF.

This study concluded **that the workload was «Medium»** with no significant difference between the two sectors of activity. This study was performed in Ramadan 2015 when the **mean** fasting duration was 15 hours / day in a region characterized by a semi-arid climate. **In fact, in the central part of Tunisia** the dry season extends over the majority of the year with a wet winter and low rainfall. These results are consistent with observations made by other authors (5, 20, 21). In fact, some authors explained that hormonal changes associated with dehydration or fasting, abstention from substances with negative isotropy and changes in circadian rhythm during RF may be responsible for slight changes in cardio respiratory responses to exercise with no effect on the physical health or aerobic performance of the subjects during a moderately heavy exercise (5,11). Moreover, this study included a selection bias of a healthy worker. In fact, the most vulnerable workers could have been on sick leave during the study or were not fasting (a criterion for non inclusion **in** this study) or were not assigned to high physical load workstations especially in the brickyard or the cutting work station in the textile sector.

In addition, in the brickyard sector, economic restructuring led to a consolidation of production centers, increased automation, which resulted in a further decrease in the number of employees exposed to thermal strain or in a change in the way in which they were exposed. However,

the brickyard in this study was traditional and had multiple openings allowing a ventilation of air and a reduction of thermal strain. The lack of significant difference in the estimated workload in the textile manufacturing company was related to the workstation of cutting where professional tasks involved carrying heavy loads (rolls of tissue). Moreover, during the initial interviews with these workers, a complaint concerning thermal strain inside the company was recurrently **attributed** to the roof of this company made of metal sheet sin the absence of a source of air ventilation.

In this study, the workload was «medium » during RF and outside Ramadan (in both cold and hot seasons) with no significant difference. Indeed, studies have estimated the acclimatization time of workers in hot countries like Tunisia at five days (22). Indeed, the body gradually learns to sweat earlier, more evenly on the surface of the skin and without losing as much mineral salts (22).

This study had some limitations. A primary limitation was the bias of a healthy worker that could explain the adaptation to RF and hot strain during work. In addition, the cardiofrequencemeter used for HR recordings generated 13 non-interpretable recordings. Yet, it is worth noting that the strength of the study is its cohort prospective nature, the choice of two groups of comparable subjects (in terms of age and BMI) and the objective assessment of the physical workload. However, the results of this study are to be interpreted with caution; because there is a selection bias: that is the healthy worker. In addition, the thermal comfort was not evaluated in this study. A preventive approach should be centered on the health comfort and safety of workers.

CONCLUSION

The physical workload level was estimated as **«Medium»** despite being measured during Ramadan in a hot season, when the mean duration of fasting exceeded15hours/day and in two companies where workers complained about thermal strain, Moreover, physical workload level during Ramadan did not differ significantly from that outside **the month of** Ramadan both in hot and cold seasons.

· Conflict of Interest

All authors agree with the content of the manuscript. There are no conflicts of interests
between or among authors.

· Ethical Approval

This article does not contain any studies with animals performed by any of the authors.

All participants gave informed consent for the research and their anonymity was preserved. **The University Hospital Taher Sfar Mahdia** (Tunisia) ethical committee approved the study.

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