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Effects of Length of Time of Fasting upon Subjective and Objective Variables When Controlling Sleep, Food and Fluid Intakes

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Abstract**—**Ramadan requires individuals to abstain from food and fluid intake between sunrise and sunset; physiological considerations predict that poorer mood, physical performance and mental performance will result. In addition, any difficulties will be worsened because preparations for fasting and recovery from it often mean that nocturnal sleep is decreased in length, and this independently affects mood and performance.

A difficulty of interpretation in many studies is that the observed changes could be due to fasting but also to the decreased length of sleep and altered food and fluid intakes before and after the daytime fasting. These factors were separated in this study, which took place over three separate days and compared the effects of different durations of fasting (4, 8 or 16h) upon a wide variety of measures (including subjective and objective assessments of performance, body composition, dehydration and responses to a short bout of exercise) - but with an unchanged amount of nocturnal sleep, controlled supper the previous evening, controlled intakes at breakfast and daytime naps not being allowed. Many of the negative effects of fasting observed in previous studies were present in this experiment also. These findings indicate that fasting was responsible for many of the changes previously observed, though some effect of sleep loss, particularly if occurring on successive days (as would occur in Ramadan) cannot be excluded.

Keywords**—**Drinking, Eating, Mental Performance, Physical Performance, Social Activity, Blood, Sleepiness.

I. Introduction

THERE are few detailed accounts of the several effects that arise during the course of a day in Ramadan due to fasting. In many of these accounts, the studies are restricted, in that they are descriptive only; moreover, subjects have been free to choose their activities, times of sleep and naps and, apart from when fasting, the timing and type of food and fluid taken in. Whilst this reflects the position that exists in Ramadan, it produces interpretive difficulties. Thus, it cannot be deduced if a measured change in a variable (mental or physical performance, for example) is due to a lack of food and fluid intake and/or changed fatigue due to altered sleep times. As indicated in a review of the relevant literature and basic physiology, any of these factors could lead to the observed results.

The present study, an intervention study, has been planned to deal with some of these limitations. Varieties of variables were measured at the same time of day (to remove circadian effects) on three test days, after subjects had undergone different lengths of fasting. By contrast, food intake during the evening before the test day (supper) and the length of sleep before the test days were unchanged. The lengths of fasting were 4h, 8h or 16h, these being administered in random order for the group as a whole.

With such a protocol, any changes in the measured variables cannot result from changes in sleep length, the size of supper the previous night (such changes being present in other studies and complicating interpretation of the results) or circadian changes; rather, they must reflect the duration of prior fasting. Accordingly, the analysis will focus the effects of specific durations of fasting upon the measured variables. It is hypothesised that general performance will deteriorate in proportion to the duration of fasting.

II. Method

A. Participants

Twelve subjects (eight males and eight females, mean age 34.4 y (SD=3.2), height 1.74m (SD=0.09) took part in the study. Subjects were recruited from young women soccer team, Tripoli, Libya by word-of-mouth. Subjects volunteered to participate in the study with the understanding that participation was not monetarily compensated and they could withdraw at any time without giving any reason and with no negative consequences.

B. Procedures

For the two days before each of the three parts of the study, the subjects were required to have normal sleep times and normal eating habits (breakfast, lunch and evening meal), with a small supper before retiring. They were also asked to ensure that they ate the same type of supper and slept the same number of hours before each of the test days. Performance and other variables (see below) were assessed at 08:00, 12:00 and 16:00h of each test day. The intervention, which was designed to change the length of fasting before making the measurements (always at 16:00h), consisted of three parts, their order being randomised for the group as a whole. The three parts were:

A. Supper before retiring but no breakfast and no lunch, and no fluid intake apart from a glass of water at 08:00h - a fasting period, by 16:00h, of 16 hours. This is called the Fasting condition.

B. Supper before retiring and a standard breakfast (at 08:00h) including a glass of water, but no lunch or other fluid

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intake - a fasting period, by 16:00h, of 8 hours. This is called the Breakfast condition.

C. Supper before retiring, a standard breakfast (at 08:00h) including a glass of water, and a standard lunch (at 12:00h) - a fasting period, by 16:00h, of 4 hours. This is called the Control condition.

C. Measurements and Preparation

On the three test days, subjects came to the laboratory at 08:00, 12:00 and 16:00h. On each occasion, the following variables were measured.

1. Actimetry

This was measured from 20:00h on the day before each test day. Actimetry is a non-invasive and objective measure of physical activity, and has been widely used to investigate amounts of physical activity as well as to compare waking activity with sleeping inactivity [1]. The apparatus (Actiwatch AW4 Software England) was worn on the non-dominant wrist and was set to record activity at 1-min intervals. The activity records were down-loaded onto a laptop computer at 17:00h for later analysis each time the subject came to the laboratory.

2. Questionnaires

These were based upon those used previously [10] and assessed food and fluid intakes, sleep, and subjective estimates of mood, mental performance and physical performance.

3. Body Mass and Urine Osmolality

In addition to body mass (Seca 702, Seca GmbH & Co.KG, Hamburg, Germany), the indirect measure of water content, urine osmolality (Osmocheck Pocket Pal OSMO, Vitech Scientific Ltd, Japan) was measured

4. Performance Measures - Throwing Darts

This is a measure of hand-eye co-ordination [2], [3]. The subjects threw darts at a circular target (20cm diameter) placed on the wall at a distance of 2.37 metres; the target consisted of 10 concentric rings of diameter 2cm, 4cm, 6cm,……20cm. Participants were instructed to stand 2.37m away from the target and to throw one dart (Unicorn Precision darts, 24g, Unicorn Products Ltd, England) a total of 20 times at the target. After each throw, the score for each dart was measured (according to which of the rings the dart was in) and then the dart was collected for the next throw. A dart in the innermost ring scored 10 points, in the next ring scored 9 points, and so on until a dart in the outermost ring scored 1 point. When a dart missed the target, the score was recorded as zero (a "miss"), regardless of the size of the miss. (See Appendix 2).

D. Exercise

This was on a cycle ergometer (Ergo Bike Premium 8i from Germany's DoumDedronic). The trial started at 120 watts and then increased by 10 watts per minute to a final value of 160 watts, which was maintained for the last minute, the trial taking 5min to complete. The subjects chose the rate of pedalling.

Before and immediately after each bout of exercise, the respiratory exchange ratio (RER), blood lactate and heart rate were measured. For the measurement of RER, Douglas bags and standard equipment for measuring gas volume and oxygen and carbon dioxide concentrations (Servomax Gas Analyser, Cranlea and company, Birmingham) were used. Blood lactate was measured in a finger-prick sample and analysed by a Lactate Pro Test Meter (Model LT7010, ArfrayInc, Kyoto Japan). Standard healthcare precautions were taken for blood sampling and analysis (See Appendix 1). Heart rate was measured using a monitor (Polar, Kempele, Finland) strapped to the chest and a data logger attached to the subject's wrist. Immediately after exercise, subjects were asked to assess their perceived exertion after exercise using the Borg scale.

E. Treatment of Results

1. Questionnaires

The questionnaire for 09:00h required information from the subjects about the previous night's sleep (section A), their fluid intake (section B), food intake (section C) and activities (section D) before sunrise. The questionnaires at 8:00h, 12:00h and 16:00h asked the same information but the subjects were instructed that their answers should apply to the interval since answering the previous questionnaire. That is, the questionnaires at 8:00h and 12:00h included periods of fasting (Ramadan) and that at 16:00h, information about activities after sunset. For these last three times and questions about daytime naps rather than nocturnal sleep were asked.

"Fluid scores" and "food scores" were calculated for each subject and time interval as previously devised by [10], [11]. These scores ranged from 0-4 and were semi-quantitative estimates of total fluid or food intake during this interval. They were calculated as follows. For the total fluid intake score: "0" represented no intake; "1" indicated a "sip"; "2", less than 1 glass/cupful; "3", 1 glass/cupful; and "4", more than 1 glass/cupful. For the food intake score: "0" represented no intake; "1" indicated a "snack"; "2", a "small meal"; "3", a medium-sized meal; and "4", a large meal

2. Actimetry

The Actimetry record was divided into three sections: the middle three hours of sleep (assessed from the activity record which clearly indicated times of retiring and rising), a two-hour "morning" section (09:00 h to 11:00 h) and a two-hour "afternoon" session (13:00 h to 15:00 h). For each of these sections, the summed activity count was used.

3. Throwing Darts

The first and last three throws were excluded, to allow for any effects due to "getting going" and being "nearly finished" [3]. The participants were not aware that the results from some of the throws would not be analysed. The central 14 scores were used to assess accuracy in two ways: the total score and the number of "misses" (zero scores)

4. Statistics

Unless stated otherwise, the data were analysed by the means of the Statistical Package for Social Science (SPSS) for Windows, version 17, using a two way Analysis of Variance

(ANOVA) with repeated measures model. The main factors were Condition (3 levels: Control, Fasting and Breakfast) and Time of Day (3 levels: 08:00, 12:00 and 16:00 h). To correct for violations of sphericity, the degrees of freedom were corrected by using either Huynh-Feld (>0.75) or Greenhouse-Geisser (<0.75) in accordance with two way repeated measures ANOVA assumptions (Field, 2000). Significance was set as P<0.05.

III. Results

A. Questionnaires

1. Sleep Times and Food and Fluid Intakes

The questionnaires were inspected to ensure that the subjects had adhered to the protocol with regard to food and fluid intakes. In addition, it was possible to assess that each subject's time in bed was similar on the three occasions (less than 30min differences for any subject), and that no daytime naps were taken during the experimental days.

Fluid and food intakes during supper the day before each of the three test days were compared (Fig. 1). Water was almost universally drunk, tea or coffee were drunk about 0.6 of possible occasions and fruit juice on about 0.4 of possible occasions. These differences in frequency of intake between types of drink were significant (P=0.01, Cochran) but the frequencies did not differ significantly between the three test days (P=0.51, Cochran), again indicating that subjects adhered to the requirements of the protocol.

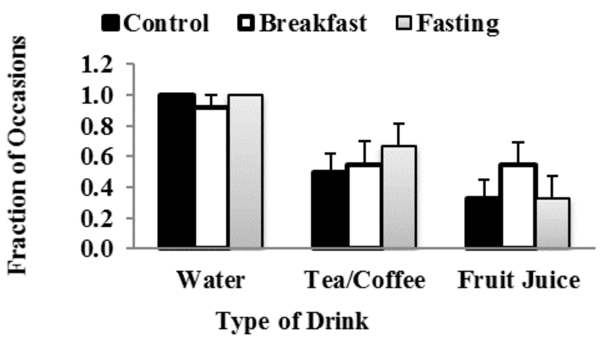


Fig. 1 Fraction of possible occasions that different types of fluid were drunk during supper just before the Control, Breakfast and Fasting days. For calculation of "Fraction of Possible Occasions"

2. Activities Performed

There was a significant difference between Control, Breakfast only and Fasting days in the amount of physical activity performed ($F_{1.7, 19.2} = 9.46$, $P = 0.002$), this decreasing in the sequence: control, breakfast, fasting (Fig. 2 A). There was also a highly significant effect of Time of day ($F_{1.9, 21.3} = 18.4$, $P<0.0005$), activity being least at 08:00 h. There was no significant interaction between Day x Time of day ($F_{2.9, 32.3} = 0.17$, $P = 0.91$).

Mental activity also showed a significant effect of Day ($F_{1.5, 16.3} = 5.65$, $P = 0.020$), decreasing in the sequence: control, breakfast, fasting (Fig. 2 B). There was a significant effect of Time of day ($F_{1.8, 19.4} = 20.16$, $P<0.0005$), values at 08:00h being lower than at the other two times of measurement. There was no significant interaction between the two factors ($F_{2.8, 30.9} = 0.14$, $P=0.93$).

Social activity showed a significant difference between the three types of day ($F_{1.7, 18.8} = 4.78$, $P = 0.025$) with values decreasing in the sequence: control, breakfast fasting (Fig. 2 C). There was a significant difference between times of day ($F_{1.7, 19.0} = 5.26$, $P = 0.018$), activity at 08:00 h being less than at the other, two times of day. There was no significant interaction between the factors ($F_{2.8, 30.6} = 0.23$, $P = 0.87$).

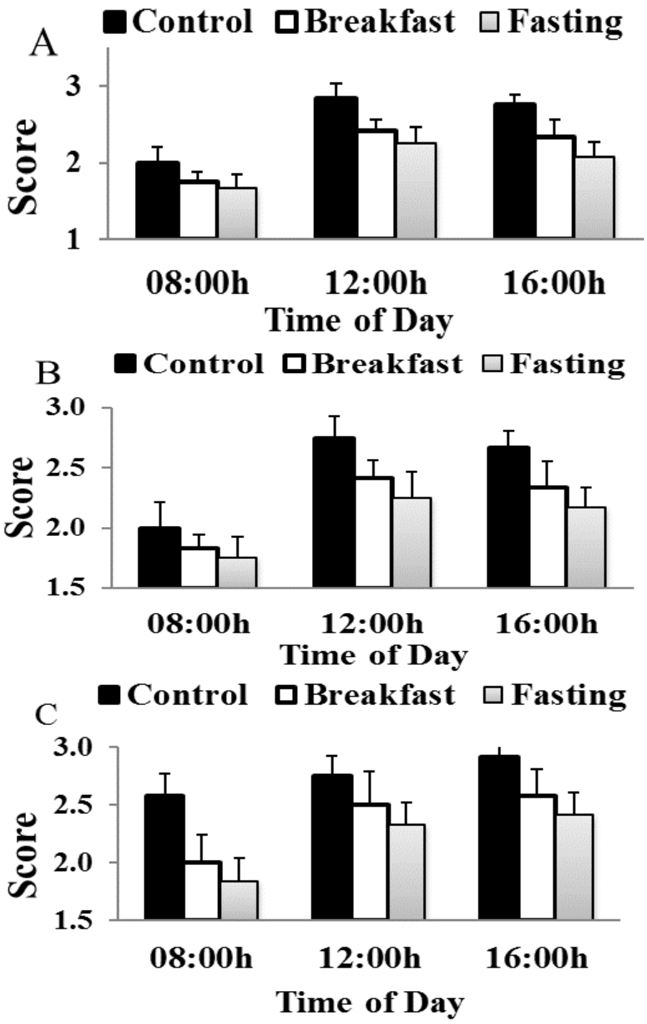


Fig. 2 Scores for A physical activity, B mental activity and C social activity during Control, Breakfast and Fasting days. Mean +SE

3. Activities Wished for

The amount of physical activity wished for (Fig. 3) showed a marginal effect of Day ($F_{1.5, 16.9} = 3.52$, $P = 0.063$), with a trend for a decrease in the sequence: control, breakfast, and fasting. There was a significant effect of Time of day ($F_{1.2, 13.2} = 7.48$, $P = 0.014$), values decreasing from 08:00 h to 16:00 h. There was no significant interaction between the two factors ($F_{2.7, 29.8} = 0.08$, $P =0.96$).

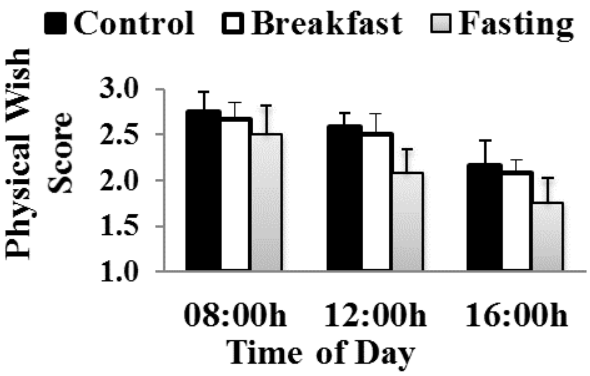


Fig. 3 The effects of time of day and condition (Control, Breakfast and Fasting) upon physical activity wished for. Mean + SE

For mental activity wished for (Fig. 4), there was a significant effect of day ($F_{1.8, 19.5} = 12.29$, $P = 0.001$), amounts decreasing in the sequence: control, breakfast, and fasting. Also, there was a significant effect of Time of day ($F_{1.9, 20.7} = 24.04$, $P<0.0005$), values at 08:00 h being lower than at the other two times. There was no significant interaction between the condition and the time of day ($F_{3.0, 33.0} = 0.10$, $P= 0.96$).

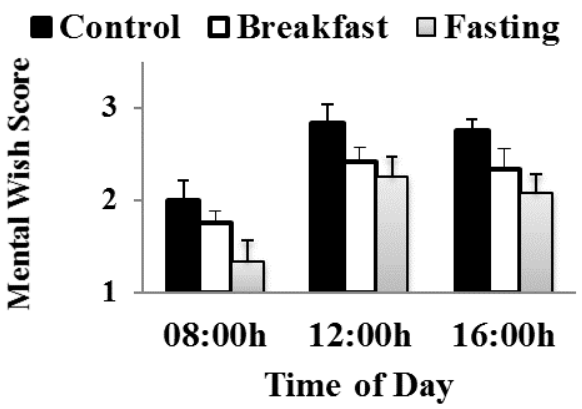


Fig. 4 The effects of time of day and condition (Control, breakfast only and Fasting) upon mental activity wished for. Mean + SE

4. Perceived Sleepiness

For perceived sleepiness (Fig. 5), there was an increasing sequence: control, breakfast, fasting, but this was not significant statistically ($F_{1.5, 16.4} = 2.53$, $P = 0.12$). However, there was a significant effect of Time of day ($F_{1.8, 19.9} = 5.86$, $P = 0.012$) with sleepiness at 08:00 h being significantly higher than at the other two times of measurement. There was no significant interaction between Day x Time of day ($F_{2.8, 30.6} = 0.21$, $P= 0.88$).

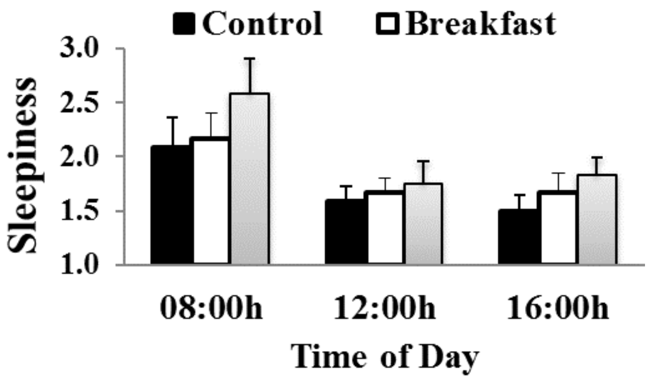


Fig. 5 The effects of time of day and condition upon perceived sleepiness. Mean + SE

5. Urine Osmolality

There were significant effects of Day ($F_{1.9, 20.8} = 28.3$, $P<0.0005$), Time of day ($F_{1.2, 13.5} = 10.4$, $P<0.005$) and a significant interaction between the Day x Time of day ($F_{2.8, 30.9} = 28.1$, $P<0.005$) (Fig. 6). The significant interaction arose because, whereas urine osmolality was similar on all days at 08:00 h and fell to lower values on control days (due to fluid intake), it rose on the other days when fluid intake was prohibited (after 12:00 h on the day "breakfast", when breakfast but no lunch was taken, and after 08:00 h and 12:00 h on the "fasting" day, when neither breakfast nor lunch was taken).

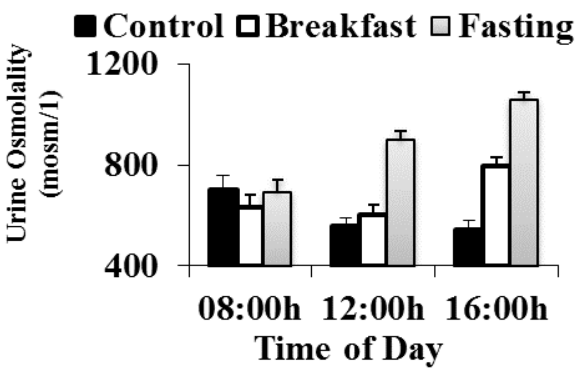


Fig. 6 Urine osmolality during the daytime in the three experimental conditions. Mean + SE

6. Actimetry

Fig. 7 shows the summed activity scores at the three times of day. There was no significant effect of day ($F_{1.1, 11.7} = 1.58$, $P = 0.24$) but a highly significant effect of Time of day ($F_{1.3, 14.7} = 14.87$, $P = 0.001$), due to the low values during sleep. There was no significant interaction between Day x Time of day ($F_{2.2, 24.3} = 1.08$, $P = 0.36$), indicating that objective measures of activity showed no significant differences between the three experimental days.

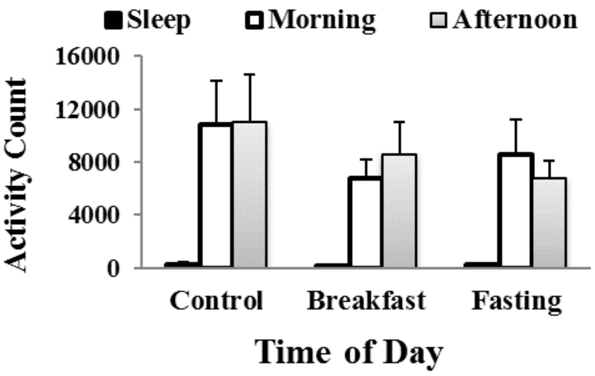


Fig. 7 Effects of time of day and conditions upon summed activities. Mean + SE. For definitions of Sleep, Morning and Afternoon periods, Objective measures of performance - throwing darts

Total Scores for darts (Fig. 8) showed no significant effect of Day ($F_{1.8,19.3}$=0.05; P=0.93), no significant effect of Time of day ($F_{1.7,19.1}$ = 1.12, P = 0.35) and no significant interaction between Day x Time of day ($F_{2.9,32.4}$ = 1.24, P = 0.34).

The number of misses, or 'zero', scores (Fig. 9) also showed no significant effects of Day ($F_{1.9,\ 21.6}$=1.07; P=0.34), Time of day ($F_{1.8,\ 19.9}$ = 0.65, P = 0.52) or interaction ($F_{2.8,\ 30.4}$=1.70, P = 0.19).

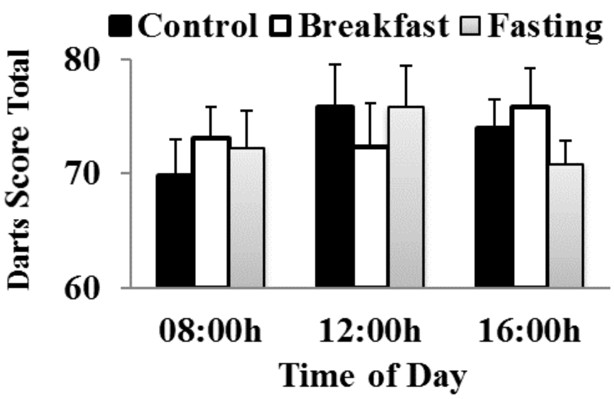


Fig. 8 Total scores for darts 4-17 on control, breakfast only and fasting days at the 3 times of measurement. Mean + SE

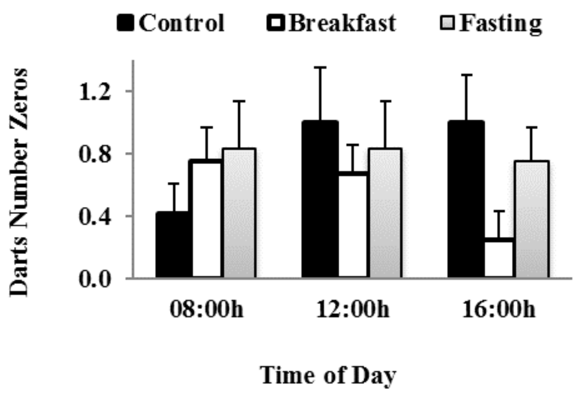


Fig. 9 Mean number of zeros scored. Mean + SE

7. Changes Produced by Exercise

Body mass decreased slightly after each bout of exercise (Fig. 10). However, these falls were not significantly different between Day ($F_{1.1,\ 12.2}$ = 0.78, P = 0.41) or Time of Day ($F_{1.4,\ 15.8}$ = 0.21, P = 0.74), and there was no significant interaction between the two factors ($F_{2.7,\ 30.2}$ = 0.57, P = 0.63).

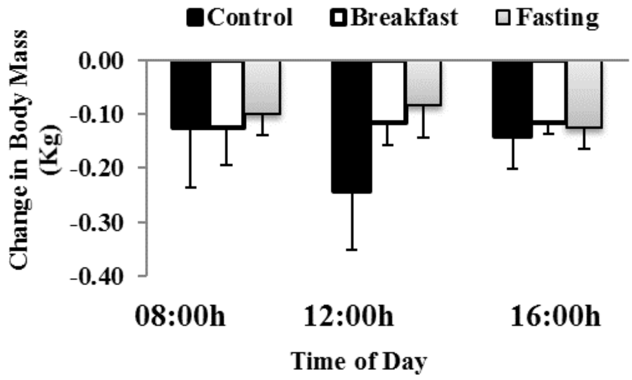


Fig. 10 Fall in body mass-produced by exercise. Mean + SE

8. Respiratory Exchange Ratio (RER)

Fig. 11 shows the increases in RER produced by exercise. The increase depended significantly upon Day ($F_{1.3,\ 14.2}$ = 5.29, P = 0.030), being significantly greater on the control day, and there was a marginal effect of Time of day ($F_{1.4,\ 15.2}$ = 2.85, P= 0.10), the rise being least at 16:00 h. During the breakfast and fasting days, these effects of time of day were far less marked, as a result of which there was a significant interaction between Day x Time of day ($F_{2.7,\ 29.6}$ = 3.49, P = 0.032).

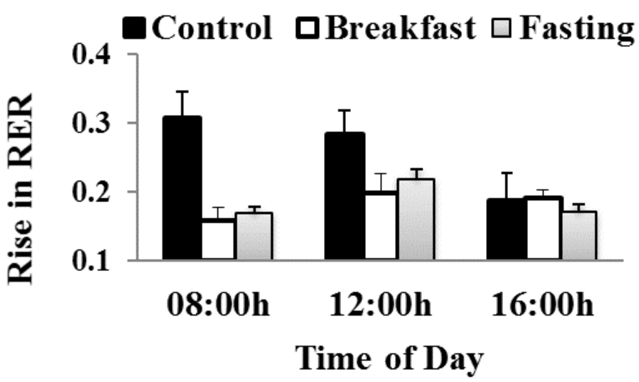


Fig. 11 Changes in RER produced by exercise. Mean +SE

9. Lactate

Blood lactate levels rose after exercise (Fig. 12), the rises being most marked on the control day ($F_{1.2,\ 13.7}$ = 11.11, P= 0.003). The rise was also greater as the day progressed ($F_{1.6,\ 18.0}$ = 10.68, P = 0.001), but this increased rise was less marked on breakfast and fasting days, as a result of which there was a significant interaction between Day x Time of day ($F_{2.3,25.4}$ = 7.32, P = 0.002).

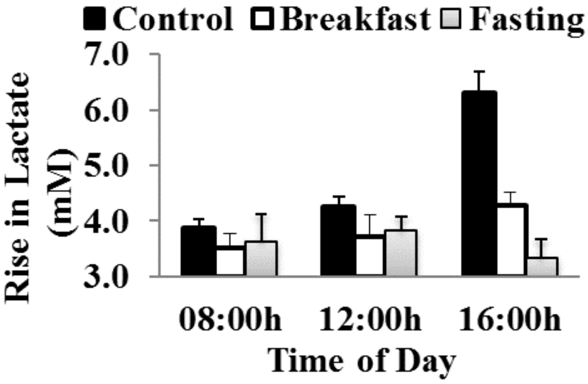


Fig. 12 Lactate rise following exercise at different times of day and during Control, Breakfast only and Fasting days. Mean + SE

10. Heart Rate

Heart rate increased markedly after exercise (Fig. 13). This rise depended upon the Day ($F_{1.3, 14.1}$ = 46.48, P<0.0005) with the rise increasing progressively with the sequence: control, breakfast, and fasting. There was no significant effect of Time of day ($F_{1.8, 19.3}$ = 2.10, P = 0.15) and no significant interaction ($F_{3.1, 34.4}$ = 2.17, P = 0.11).

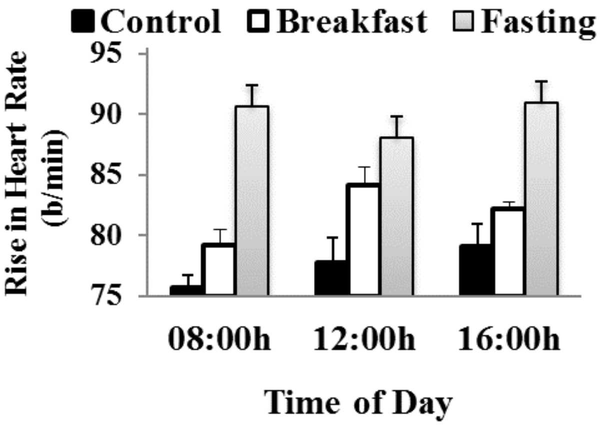


Fig. 13 Rise in HR produced by exercise at different times of day on Control, Breakfast only and Fasting days. Mean + SE

11. Rating of Perceived Exertion (RPE)

Fig. 14 shows the ratings of perceived exertion after the bout of exercise. There was a significant effect of Day ($F_{1.4, 15.9}$ = 46.6, P<0.0005), with perceived exertion increasing with the sequence: control, breakfast, and fasting. There was also a significant effect of Time of day ($F_{1.7, 18.9}$ = 50.87, P<0.0005), exertion being perceived as greater later in the day. There was no significant interaction between Day x Time of day ($F_{2.4, 26.6}$ = 0.66, P = 0.55).

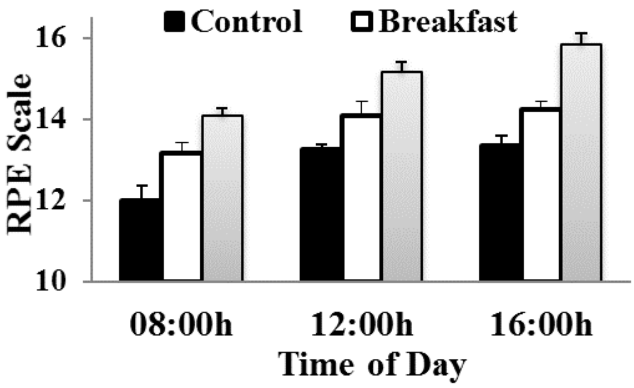


Fig. 14 Rating of perceived exertion (RPE) after bout of exercise. Mean + SE.

V. Discussion

Since the subjects' sleep times and the amounts of food and fluid taken in the days before the test days did not differ, the observed differences between the three parts of the experiment can be attributed to the lack of food and fluid intakes during the daytime rather than to a lack of sleep the previous night or altered eating habits during the previous evening. In support of the view that sleep was unchanged, the amount of sleepiness (Fig. 5) did not vary significantly with the amount of fasting. The observation that sleepiness decreased progressively from 08:00 h to 16:00 h is to be expected [12] and supports the view that subjects were responding normally to the demands of wake time. The actimetry record also (Fig. 7) supports the view that sleep was similar in the three parts of the experiment.

Subjective estimates of the amounts of activity performed in the daytime, whether physical, mental or social activity (Fig. 2), indicate that less activity was performed when fasting, a result in accord with that found previously [10], [11]. Inspection of Fig. 7 suggests that the activity counts during the daytime were lower on breakfast and fasting days compared with the control days, even though the differences were not statistically significant. Wrist actimetry is normally a reliable indicator of general physical activity [1]. However, that there are some circumstances - if an activity is stressful, requires large amounts of isometric contraction, or involves large amounts of hand movements, for example – where this parallelism between actimetry and subjective assessments fails [8]. There is also the possibility that the subjective estimates might be affected by fasting [4]. Further work needs to be performed to clarify the reasons for this possible discrepancy between objective and subjective measures of amounts of activity.

Wished-for physical (Fig. 3) and mental activity (Fig. 4) were both negatively affected by the length of time the individuals had been fasting, a result found previously in the literature [4], [10], [11]. The time-of-day effects that were present (wishing for more mental activity and less physical activity as the day progressed) are in accord with the literature on the subject [5], [12]. The rise in mental activity is probably due to effects of "waking up" and the fall in physical activity due to the onset of physical fatigue. It is predicted that both variables would show a decline if measured later in the day, due to the combined effects of increased time awake, general fatigue and preparations for sleep driven by the body clock.

Osmotic pressure (Fig. 6) showed changes that would be predicted. Thus, values were quite high and very similar in the three parts of the experiment on rising, indicative of mild dehydration due to no fluid intake since suppertime. After this, the values fell on the control day due to fluid intake and the restoration of fluid balance. On the day when breakfast only was taken, values also fell initially by a similar amount (due to fluid intake) but then rose after 12:00 h due to fluid restriction. When fluid was not allowed (the fasting day), the osmolality increased at 12:00 h above its rising value with a further rise by 16:00 h. Such results indicate clearly that fluid restriction results in dehydration, the degree of which is quite marked by 16:00 h on the fasting day. Previous studies [10], [11] have shown that this dehydration is normally combated in the evening by increased intakes of fluid, particularly water and fruit juice which do not have diaphoretic or diuretic properties.

Since dehydration has a negative effect upon physical performance, [4], [6] deteriorations in these variables would be predicted during the "breakfast" and, particularly "fasting" test days. Such deterioration has already been discussed with regard to the subjective measures of performance. In contrast, performance at throwing darts (Figs. 8, 9), both the total scores achieved and the number of misses, showed no effects of fasting. Moreover, there was no time-of-day effects such as had been shown to exist in previous studies, [2], [3]. A detailed explanation of this result is unclear; whatever it might be, it seems that such a task, as performed in the current study, was inadequate to assess any decrement in performance that might have existed.

On the other hand, decrements due to the amount of time spent fasting were present when the effects of a bout of exercise were considered. Exercise caused small falls in body weight (Fig. 10), probably the result of sweating to remove excess body heat, but the rate of sweating was not measured. Even though the changes did not depend significantly upon Day or Time of day, there is the suggestion that the falls were greater on the control days than when fasting; accepting that the urine osmolality indicated that dehydration increased with the length of fasting (Fig. 6), a reduced rate of sweating as a result of this would be predicted, and this prediction agrees with the present results.

Increasing dehydration (Fasting > Breakfast > Control) would also be expected to alter the effects of exercise. This is illustrated by perceived exertion (RPE) (Fig. 14). The greater the amount of fluid restriction, the greater was the effort perceived to be, even though the exercise itself was of a constant load, and the perception of effort increased as the day progressed - that is, as the degree of dehydration due to fluid restriction became more marked (compare the profiles of Fig. 6 and 14). Such results accord with the literature on the effects of dehydration, [4], [7]. RPE is also likely to rise if core temperature raises more with exercise, as would be the case if sweating were inhibited by dehydration.

The bout of exercise also caused rises in RER, lactate and heart rate, all of which would be predicted from basic physiology. However, as found previously, [9]. The effects of time of day and fasting were complex. The increase in RER (Fig. 11) was greatest on control days, consonant with the view that glucose was a more important substrate during exercise than on the two days with fasting. On days with normal food and fluid intake (the Control day in this study), glucose metabolism (from the food eaten) tends to increase during the course of the day so that, by the afternoon, glucose is the main substrate for metabolism. Therefore, the switch to glucose metabolism produced by exercise is likely to be less marked in this circumstance, and this might account for the decreased rise in RER produced by exercise at 16:00 h compared with 08:00 h during the control part of the experiment (see Fig. 11). With a restriction of food intake, metabolisms tends to rely more upon fatty acids, and this might account for the smaller rises in RER observed on "breakfast" and "fasting" days. Whatever the detailed explanation, there is evidence that the increased metabolism required by exercise was accomplished differently when food intake had been restricted. In agreement with this view, exercise increased blood lactate levels (Fig. 12), this rise being greatest on the control day (when glucose is likely to have been the main substrate) whereas fat metabolism would have played a more important role on fasting days.

Heart rate also rose following exercise (Fig. 13) and the size of this rise was proportional to the duration of fasting. Since the amount of exercise did not change, these rises are an objective indication of the "stress" caused by the bout of exercise. The stress can arise directly, from restrictions to food intake (reducing energy stores) and fluid intake (causing dehydration and reducing venous return, so requiring an increase in heart rate to maintain blood pressure); it can also rise indirectly, due to a fall in motivation of the subject, any task then being perceived as more difficult to perform (compare the profiles of Figs. 13 and 14 where the effects of duration of fasting upon the rise in heart rate and subjective (RPE) estimates of stress match each other closely. It is widely reported that dehydration and lack of food intake decrease physical and mental performance, cause a given activity to be more difficult to achieve, and result in a workload being perceived as being more difficult (reviewed in [4], [7], [9].

VI. General Conclusions

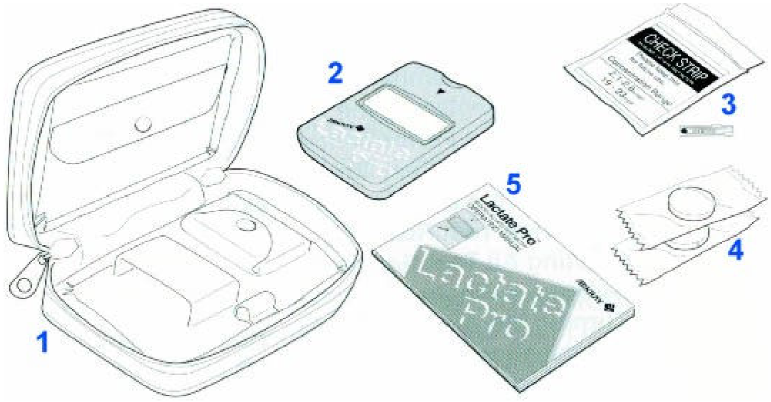
Taking all the results together, it is concluded that restriction of food and fluid intakes for a single day in a laboratory environment produces widespread effects upon the individual with regard to subjective perceptions of daily activities, perceived workload when performing exercise, and objective measures of "stress" and changes to metabolism produced by a bout of exercise.

These changes are associated with the amount of dehydration produced by the length of restriction of fluid intake, as assessed from urine osmolality, and causal links are possible. For other variables, including actimetry and performance accuracy at throwing darts, the effects of fasting were not as clear statistically, even though they also tended to show deterioration later in the daytime.

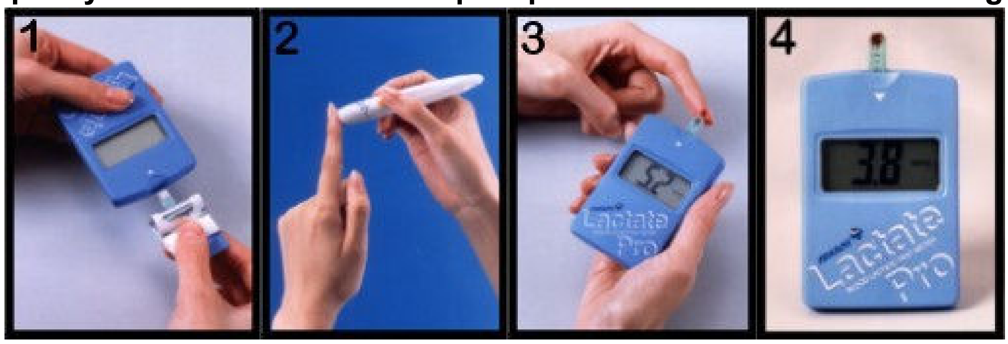
Even though the changes that have been observed are very similar to those observed of Ramadan, [9]-[11]. This ambiguity was that Ramadan is associated with sleep loss as well as fasting. In the current study, sleep loss was avoided and food and fluid intakes the previous suppertime were controlled, and so the changes observed can be attributed to effects of food and fluid restriction.

APPENDIX 1. BLOOD LACTATE

Lactate Pro Meter Set



Speedy measurements and simple operation - Blood Lactate Testing



Insert the test strip into the strip inlet of the meter.	Collection of the blood.	Blood is automatically aspirated and measurement begins.	The measurement result is displayed in 60 seconds

Fig. 15 Blood lactate apparatus

APPENDIX 2. ACCURACY OF THROWING DARTS

Hand-Eye Coordination Test

- 20 shots Dominant hand Performance
- Total score
- average score
- Distance (2.37m)

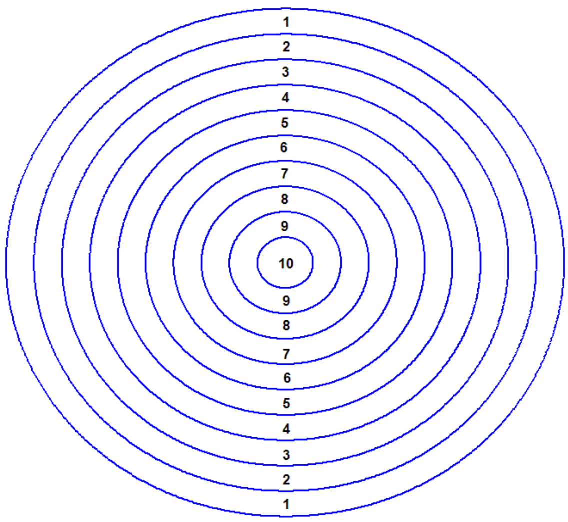


Fig. 16 Accuracy of throwing darts

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