In conclusion, patients nutrition/carbohydrates weekday • nutrition/lipids (TG) concentrations may be an independent atherogenic risk factor. All interventional studies have been based upon fasting or postprandial TG concentrations, yet nonfasting TG concentrations seem to be more strongly associated with CVD than fasting TG concentrations (3, 4), as substantiated in a Mendelian randomization study (5).

An improved understanding of biological variation in clinically measured compounds in human material may be useful for many purposes in clinical chemistry (6). There may, however, be several sources of variation that contribute to the biological variation. Many compounds such as CH, TG, and other lipids have diurnal and seasonal variation, in addition to variation due to lifestyle behavior (7), but little is known about variation due to weekdays.

In a study with 807 8- to 11-year-old children, fasting TG concentrations were found to be 28% higher on Mondays compared with Fridays (8). However, to our knowledge, no study has investigated the weekday variations of TG concentrations in a large sample, including adults.

Therefore, the aim of this study was to investigate whether and to what extent TG concentrations vary according to the day of week using approximately 1.8 million unselected blood samples analyzed at hospitals in the Capital region in Denmark from 2008 through 2015. We hypothesized that TG concentrations would be higher on Mondays compared with Fridays.

### MATERIALS AND METHODS

The present study was based on anonymized data extracted from a common clinical laboratory information system (Labka II; CSC, Tysons, VA). The database contains millions of stored test results from in- and out-patients in the Capital region of Denmark.

**Abstract**  
Triglyceride (TG) concentration is used as a marker of cardiometabolic risk. However, diurnal and possibly weekday variation exists in TG concentrations. The objective of this work was to investigate weekday variation in TG concentrations among 1.8 million blood samples drawn between 2008 and 2015 from patients in the Capital region of Denmark. Plasma TG was extracted from a central clinical laboratory information system. Weekday variation was investigated by means of linear mixed models. In addition to the profound diurnal variation, the TG concentration was 4.5% lower on Fridays compared with Mondays ($P < 0.0001$). The variation persisted after multiple adjustments for confounders and was consistent across all sensitivity analyses. Outpatients and in-patients, respectively, had 5.0% and 1.9% lower TG concentrations on Fridays compared with Mondays (both $P < 0.0001$). The highest weekday variations in TG concentrations were recorded for out-patients between the ages of 9 and 26 years, with up to 20% higher values on Mondays compared with Fridays ($all P < 0.05$).

In conclusion, TG concentrations were highest after the weekend and gradually declined during the week. We suggest that unhealthy food intake and reduced physical activity during the weekend increase TG concentrations which track into the week. This weekday variation may carry implications for public health and future research practice. —Jaskolowski, J., C. Ritz, A. Sjödin, A. Astrup, P. B. Szecsi, S. Stender, and M. F. Hjorth.

**Weekday variation in triglyceride concentrations in 1.8 million blood samples. J. Lipid Res. 2017. 58: 1204–1213.**

**Supplementary key words** diet and dietary lipids • lipid biochemistry • nutrition/lipids • nutrition/carbohydrates • patients • weekday differences

A high concentration of plasma cholesterol (CH) has for years been considered a major risk factor for CVD (1, 2), and treatment has focused on lowering total non-HDL-CH. However, some observational studies and a meta-analysis have indicated that high plasma triacylglycerol/triglyceride (TG) concentrations may be an independent atherogenic risk factor. All interventional studies have been based upon fasting or postprandial TG concentrations, yet nonfasting TG concentrations seem to be more strongly associated with CVD than fasting TG concentrations (3, 4), as substantiated in a Mendelian randomization study (5).

### Supplementary key words

- diet and dietary lipids
- lipid biochemistry
- nutrition/lipids
- nutrition/carbohydrates
- patients
- weekday differences

**Abbreviations:** ALAT, alanine transaminase; CH, cholesterol; CHO, carbohydrate; Hgb, hemoglobin; n-3 PUFA, long chain polyunsaturated omega-3 fatty acids; PA, physical activity; TG, triglyceride.

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Weekday variation in triglyceride concentrations

with a population of about 1.8 million inhabitants. The samples were commissioned by general practitioners, specialists, and doctors during everyday life or hospitalization. Blood samples were obtained at various time points and for multiple reasons; thus, for routine checkups, suspicion of illness, hospital admission and readmission, during hospitalization, and before hospital discharge, they comprise measurements of various blood parameters from males and females of any age. The laboratory data were obtained from 13 hospital laboratories in the region with different instruments, varying both over time and by location. However, results were comparable due to common quality control systems and sample exchange. Most of the analyses were performed according to ISO-15189 accreditation.

The primary analytical sample comprised data from TG. Data of alanine transaminase (ALAT), hemoglobin (Hgb), and sodium were extracted to support the interpretation of the TG data. The test results for each blood sample were accompanied by information about the executive laboratory, date and time, patient-setting, fasting status, age, gender, and a unique subject identifier.

Analyses were mainly performed using Kone-lab, Espoo, Finland; Vitros 950/5.2 chemistry system (Johnson and Johnson, Rochester, NY); and Hitachi 912, Cobas Integra 400/800, Cobas Modular 6000/8000, Cobas Modular (Roche Diagnostics, Basel, Switzerland); Dimension Vista 1500 (Siemens Medical Solutions Diagnostics, Tarrytown, NY), and the Advia 120/2120 hematology system (Siemens); Sysmex XE, XI, or XN series (Sysmex, Kobe, Japan).

Colorimetric methods were used to measure TG in plasma according to the manufacturers’ protocols. The relative expanded uncertainty for CH is approximately 10%, whereas for TGs it is approximately 22-23%. Plasma ALAT was measured according to the IFCC 2002 method, plasma sodium was measured with ion-selective electrodes, and blood Hgb with a non-cyanide method on automated hematology instruments.

Statistics

Weekday variation in TG, Hgb, ALAT, and sodium concentrations was described by means of linear mixed models; one model per outcome. Observations with missing data were excluded. Linear mixed models comprised fixed effects including gender, age-group (5 year intervals), fasting-status (fasting, nonfasting), hospitals, setting [out-patient, in-patient, in-between-patient (staying at the hospital during day time, but sleeping at home)], year, month, time of the day (hour), and subject-specific random effects. If appropriate, skewed variables were log-transformed and subsequently back-transformed. The majority of the TG and ALAT data was processed by this approach; whereas for Hgb and sodium, a log-transformation of the data was not required. Results were shown as mean concentrations with 95% CI, as estimated by the package, multcomp 1.4-4 (9). The difference between Monday and Friday was assessed through a pairwise comparison using a post hoc t-test. The same approach was used to test differences between weekdays and weekend days for hydration markers (Hgb and sodium). As hydration level was expected to be different on weekdays compared with weekend days, the difference between Monday and Friday for each marker was calculated. Sensitivity analysis for TG was performed in order to evaluate the robustness of the results in respect to various characteristics. Specifically, sensitivity analyses comprised aforementioned linear mixed models stratified according to samples <3.0 mmol/l (<266 mg/dl) and ≤1.7 mmol/l (<151 mg/dl), gender, patient-status, age (by each year), fasting-status, hospital, and sample time (year, month, hour). All the statistical analyses were conducted using R version 3.2.4 (10). Significance was declared whenever P < 0.05.

RESULTS

Characteristics of the 1,828,861 observations for TG, as well as for the observations for Hgb, sodium, and ALAT can be found in Table 1. The TG observations were obtained from a total of 635,123 subjects. A total of 80.6% of the TG samples were from out-patients, as were 40.1, 41.5, and 58.5% for sodium, Hgb, and ALAT, respectively. The overall proportion of TG concentrations ≥1.7 mmol/l (≥151 mg/dl) was 32.7%; with 34.8, 34.0, 32.8, 31.3, and 29.7% for Monday through Friday, respectively. TG concentrations were 4.5% (4.3%, 4.7%; P < 0.0001) lower on Fridays compared with Mondays when using mixed models (Table 2). Furthermore, negligible differences were observed between Monday and Friday for Hgb and sodium concentrations (both P < 0.0001), whereas no difference was observed for ALAT (P = 0.11). Concentrations of Hgb on all of the weekdays were systematically higher compared with weekend days (all P < 0.0001), whereas this was the opposite for ALAT (all P < 0.0001).

Weekday variation in TG concentrations remained after stratifying on age (Fig. 1, supplemental Table 1), gender, truncation of values, fasting status, setting, hospital, year, and month (Table 3). The variation from Monday to Friday was roughly 10% for 14–26 years of age, followed by gradually decreasing variations of about 4% around age 65. The decline in variation continued, reaching nonsignificance at the age of 80 years. Only 1.4% of the <1-year-old infants and 31% of the children between 1 and 9 years were out-patients. The proportion of out-patients exceeded 50% by the age of 9 years and increased linearly to 84% until the age of 74 years (data not shown). Out-patients had a Monday to Friday difference of −5.0%, while in-patients had a difference of −1.9% (both P < 0.0001). Out-patients had systematically larger weekday variation in each of the age groups, as shown in Fig. 1. The highest variations were recorded for out-patients between 9 and 26 years of age, with up to 20% higher values on Monday compared with Friday (all P < 0.05). The differences were −5.5% and −4.4% in fasting and nonfasting samples (both P < 0.0001), respectively. In view of the different seasons, the lowest Monday to Friday variations were observed in April and July (both −3.7%, P < 0.0001).

On all weekdays, TG concentrations were lowest around 7:00 AM, ranging from 1.61 mmol/l (143 mg/dl) on Mondays to 1.52 mmol/l (135 mg/dl) on Fridays. The time trends for out-patients were in accordance with the overall data (Fig. 2). Patterns between 7:00 AM and 2:00 PM on each weekday were comparable; however with each subsequent day of the week, the TG concentrations declined. On average, the TG concentrations reached their peak at 2:00 PM each weekday with 23.3, 22.3, 24.3, 22.1, and 27.4% higher concentrations compared with concentrations at 7:00 AM on Monday to Friday, respectively. The highest number of observations was recorded at 7:00 AM with more than 50,000 observations on each weekday. After 1:00 PM the number of observations dropped rapidly to less than 700 observations at 2:00 PM on Friday. The weekday variation for plasma total-CH,
higher from Friday to Sunday compared with Monday
to in-patients and the weekday variation
from weekend days need to be interpreted with caution.

TG concentrations caused by variation in hydration level
as not present for ALAT; this speaks against an effect on
for total-CH, LDL-CH, and HDL-CH were all less than 1% (supplemental Table 2).

TABLE 1. Characteristics of the study population according to TG, Hgb, sodium, and ALAT status

| Characteristics              | TG       | Hgb      | Sodium   | ALAT     |
|------------------------------|----------|----------|----------|----------|
| Observations (n)             | 1,828,861| 3,000,000| 1,544,204| 3,000,000|
| Gender (% female)            | 48.2     | 51.3     | 50.1     | 52.7     |
| Age (years)                  | 63 (36–80)| 64 (29–84)| 67 (35–85)| 61 (28–81)|
| Setting (%)                  | In-patient     | 80.6     | 41.5     | 40.1     | 58.5     |
| In-between-patient           | 18.0     | 56.9     | 58.6     | 39.8     |
| Fasting-status (%)           | Non-fasting | 87.1     | 100      | 100      | 100      |
| Day (%)                      | Fasting     | 12.9     | —        | —        | —        |
| Monday                       | 21.0     | 19.3     | 19.3     | 20.7     |
| Tuesday                      | 22.3     | 18.4     | 18.4     | 19.9     |
| Wednesday                    | 20.0     | 17.8     | 17.5     | 18.7     |
| Thursday                     | 20.2     | 17.3     | 16.8     | 18.4     |
| Friday                       | 13.7     | 14.7     | 14.7     | 14.2     |
| Saturday                     | 1.4      | 6.3      | 6.6      | 4.0      |
| Sunday                       | 1.4      | 6.3      | 6.6      | 4.1      |
| Year (%)                     | 2008      | 1.3      | 1.2      | —        | 0.9      |
| 2009                         | 8.7      | 8.2      | —        | 7.2      |
| 2010                         | 11.2     | 10.4     | —        | 9.7      |
| 2011                         | 13.5     | 13.6     | —        | 12.8     |
| 2012                         | 14.8     | 15.5     | —        | 15.2     |
| 2013                         | 15.9     | 16.2     | —        | 16.9     |
| 2014                         | 17.0     | 17.3     | 100.0    | 18.4     |
| 2015                         | 17.6     | 17.5     | —        | 18.9     |

Data are expressed as n, median (10th to 90th percentile), or proportion.

LDL-CH, and HDL-CH were all less than 1% (supplemental Table 2).

DISCUSSION

In support of the hypothesis, TG varied according to weekandays, with higher concentrations on Mondays compared with Fridays. The overall observed variation of 4.5% between Mondays and Fridays in TG concentrations is based on more than 1.8 million samples and persisted after multiple adjustments. The phenomenon exists across gender, age, hospital, fasting state of the sample, year, month, hour of the day, and after truncation of abnormal values. The variation between Monday and Friday was negligible between the first and the second half of the study with the TG baseline value (23, 24). Even though it is evident that n-3 PUFAs reduce TG concentrations, intervention periods are commonly greater than 4 weeks with average intakes of 3–4 g of EPA and DHA daily (23, 24). Acute effects of n-3 PUFA have only been recorded with a single dose of 20 g fish oil (68% n-3 PUFAs), which reduced TG concentrations by 33% 14 h after the ingestion (25). However, daily concentrations above 2 g are difficult to obtain from the diet (26).

Previous literature shows that energy intake above the individual requirement results in the overproduction of VLDL in the liver and consequently increases TG concentrations (27–29). Current research suggests that the effect of positive energy balance on TG metabolism is determined through Friday (11) and several observational studies have shown an association between alcohol intake and increased TG concentrations (12). Although acute intake of alcohol elevates TG concentrations by roughly 15% (13) to 60% (14) 1 and 3 h after consumption of 30 g of alcohol together with a meal, TG concentration returns to baseline after an overnight fast. In support of this, the present study was unable to detect weekday variation in 3 million ALAT observations. Alcohol intake and ALAT have been linearly associated in men (15); however, the role of ALAT as a sensitive marker for acute alcohol intake is questionable, as it has a long half-life time and fluctuates within and between days (16, 17). Therefore, we cannot exclude alcohol as a mediator of the observed weekday variation in TG.

Against the hypothesis of an alcohol-mediated effect is the large TG variation in 9- to 14-year-old out-patient children in the present study, and the 28% higher TG concentrations on Mondays compared with Fridays in 8- to 11-year-old healthy children found in another Danish observational study (8). We speculate that these age groups are unlikely to consume any alcohol and our observed weekday variation in TG concentrations is, therefore, most likely not related to alcohol intake.

Previous studies suggest that carbohydrate (CHO)-rich diets induce hypertriglyceridemia (18, 19), as shown for both fructose and glucose under controlled conditions (20). Switching from a high-fat (70%) diet to a high-CHO (75%) diet, TG concentrations have been found to rise significantly within 1 week and reach their peak after 4 weeks. After shifting back, TG concentrations declined gradually over a course of weeks with the largest changes in the first week (19). In another study of 14 healthy postmenopausal women, the habitual diet was changed gradually to reduce dietary fat intake and increase CHO intake over a period of 3 months. In response, the TG concentrations increased from 2.1 mmol/l (186 mg/dl) to 2.5 mmol/l (221 mg/dl) between the first and the second half of the study with the diets comprising 60% CHO and 67% CHO, respectively (18). Fat-rich meals also have the potential to induce hypertriglyceridemia (21, 22). It has been shown that meals containing 70 g of fat raised TG concentrations by 70% with its peak at 3 h subsequent to consumption (22). Long-chain polyunsaturated omega-3 fatty acids (n-3 PUFAs), particularly EPA and DHA, are known to lower fasting TG concentrations by 20–40%, depending on the n-3 dose and the TG baseline value (23, 24). Even though it is evident that n-3 PUFAs reduce TG concentrations, intervention periods are commonly greater than 4 weeks with average intakes of 3–4 g of EPA and DHA daily (23, 24). Acute effects of n-3 PUFA have only been recorded with a single dose of 20 g fish oil (68% n-3 PUFAs), which reduced TG concentrations by 33% 14 h after the ingestion (25). However, daily concentrations above 2 g are difficult to obtain from the diet (26).

Previous literature shows that energy intake above the individual requirement results in the overproduction of VLDL in the liver and consequently increases TG concentrations (27–29). Current research suggests that the effect of positive energy balance on TG metabolism is determined
TABLE 2. Weekday variation in TG, Hgb, sodium, and ALAT status.

| Day       | TG (mmol/l)     | Hgb (mmol/l)    | Sodium (mmol/l) | ALAT (U/l) | Post Diff |
|-----------|----------------|----------------|-----------------|------------|-----------|
| Monday    | 383.52 ± 0.45  | 577.71 ± 0.78  | 138.83 ± 0.06   | 620.03 ± 0.1 | <0.0001   |
| Tuesday   | 407.97 ± 0.45  | 551.59 ± 0.78  | 138.85 ± 0.06   | 596.63 ± 0.3 | >0.11     |
| Wednesday | 366.51 ± 0.45  | 534.63 ± 0.78  | 138.87 ± 0.06   | 562.32 ± 0.3 | <0.0001   |
| Thursday  | 368.98 ± 0.45  | 519.08 ± 0.76  | 138.89 ± 0.06   | 552.75 ± 0.3 | <0.0001   |
| Friday    | 249.99 ± 0.45  | 440.55 ± 0.76  | 138.84 ± 0.06   | 425.28 ± 0.3 | <0.0001   |

Data are presented as mean and 95% CI per day using a linear mixed model adjusted for gender, age-group (5 year intervals), fasting-status (fasting, nonfasting), hospitals, setting (out-patient, in-patient). The rather small weekday variation for in-patients are autonomous in their eating and PA behavior, whereas the dietary and physical activity (PA) patterns for children are highly structured due to school during the week, until young adulthood and gradually decreased with age. The dietary and physical activity (PA) patterns for children are autonomous in their eating and PA behavior independent of weekday, whereas children are less physically active and compensate for the excess energy intake on weekend days, considering that children are less physically active and more sedentary on these days (52). Based on these results, energy imbalance may be speculated to be a rationale for the observed Monday to Friday variation. In support of this energy imbalance theory between weekdays and weekends, higher leptin and lower ghrelin have been found in children on Mondays compared with Fridays with a gradual decline from Monday to Friday (8). In the present study, Monday to Friday variations were largest in late childhood and postnatal TG concentrations by 15% and 12%, respectively (33). Multiple studies have found exercise to reduce fasting and postprandial TG concentrations (36–38). Exercise-induced effects on TG concentrations have been documented as a 12 h delay subsequent to a bout of exercise (33, 39) and the TG concentrations will remain lower than the baseline values for about 2–3 days, after which the effect fades (40–44). Various studies applied altered exercise intensity and time to determine an energy expenditure threshold of 2–3 MJ to induce a TG lowering effect (38, 45–47). A session of exercise equal to approximately 3 MJ expended energy reduces plasma TG concentrations the following day in the postprandial state by 17–33% (45–49) and in the fasting state by 15–25% (38, 45, 46, 48). Therefore, the major cause of the TG-lowering effect during weekdays is plausibly energy expenditure. Furthermore, evidence emerges that the energy expenditure threshold can also be overcome by a combination of mild dietary restriction and light exercise (50).

A recent survey found Danish children to have about 10–12% higher energy consumption on Fridays and weekends compared with the remaining days of the week with more added sugar comprising some of this difference (51). Danish adults have also been reported to consume 13% more energy during weekends with a higher sugar intake (11). There is no indication that additional exercise compensates for the excess energy intake on weekend days, considering that children are less physically active and more sedentary on these days (52). Based on these results, energy imbalance may be speculated to be a rationale for the observed Monday to Friday variation. In support of this energy imbalance theory between weekdays and weekends, higher leptin and lower ghrelin have been found in children on Mondays compared with Fridays with a gradual decline from Monday to Friday (8). In the present study, Monday to Friday variations were largest in late childhood and postnatal TG concentrations by 15% and 12%, respectively (33). Multiple studies have found exercise to reduce fasting and postprandial TG concentrations (36–38). Exercise-induced effects on TG concentrations have been documented as a 12 h delay subsequent to a bout of exercise (33, 39) and the TG concentrations will remain lower than the baseline values for about 2–3 days, after which the effect fades (40–44). Various studies applied altered exercise intensity and time to determine an energy expenditure threshold of 2–3 MJ to induce a TG lowering effect (38, 45–47). A session of exercise equal to approximately 3 MJ expended energy reduces plasma TG concentrations the following day in the postprandial state by 17–33% (45–49) and in the fasting state by 15–25% (38, 45, 46, 48). Therefore, the major cause of the TG-lowering effect during weekdays is plausibly energy expenditure. Furthermore, evidence emerges that the energy expenditure threshold can also be overcome by a combination of mild dietary restriction and light exercise (50).

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may support that eating and PA behavior are among the main drivers of this weekday variation in TG. As it was recently found that objectively measured PA of children varies considerably more between weekdays and weekend days during winter compared with spring (52), this behavior theory may be further supported by our weekday variation being largest in November, February, and March and lowest during April, May, and July.

TG concentrations fluctuate in response to dietary intake. Most individuals eat regularly throughout the day, hence TG concentrations are very dynamic and lowest concentrations are usually measured in the morning after overnight fasting. It has been shown that TG concentrations increase up to 20% and remain elevated up to 6 h subsequently to the last meal (53, 54), which has been acknowledged (55), but disregarded, due to clinical unimportance and practicalities in clinical practice (56). The present study was able to confirm this daily variation in TG with differences ranging from 22% to 27% between 7:00 AM and 2:00 PM on each weekday. Fluctuations in CH concentrations have been suggested to range between 5% and 10% (57) and are to a lesser extent affected by alcohol, total energy intake, CHO-rich diets, and exercise (14, 48, 49, 58). The present study observed only minor weekly variation for CH concentrations.

Moreover, it has been suggested that the occurrence of acute myocardial infarction, sudden death, and cardiac arrest is higher on Monday compared with the rest of the week (59–62). The Monday phenomenon has also been published for onset of ischemic stroke (63).

Strengths of the present study include the large amount of samples representing a wide range of subjects across all ages from 13 different hospitals and making subgroup analysis possible without limiting power. Furthermore, Hgb and sodium measurements were used to investigate the potential differences in hydration status. Multiple covariates were used to adjust the analyses and reduce confounding. TG measurements performed at the hospitals are in most cases not affected by the potential disease or treatment of the patients. Results for out-patients, especially, may

Fig. 1. Difference (percent) in TG concentrations from Monday to Friday by age (years) for all observations and out-patients with more than 100 observations on each day. Data are presented as the percentage difference from Monday and are based on means using a linear mixed model with gender, fasting status (fasting, nonfasting), hospitals, year, month, and time of the day (hour) as fixed effects, and subject as random effect. Additionally “All observations” are adjusted for setting (out-patient, in-patient, in-between-patient). Number of observations in out-patients ranging from 106 to 727 on each Monday or Friday during adolescence followed by gradually increasing numbers up to age 68 (n > 5,812) then decreasing gradually (n > 2,574 at age 79).
| Gender      | Monday          | Tuesday        | Wednesday     | Thursday      | Friday        | Saturday      | Sunday  |
|-------------|-----------------|----------------|---------------|---------------|---------------|---------------|---------|
| Male        | 1.50 (1.40,1.60) | 1.50 (1.40,1.60) | 1.50 (1.40,1.60) | 1.50 (1.40,1.60) | 1.50 (1.40,1.60) | 1.50 (1.40,1.60) |        |
| Female      | 1.71 (1.61,1.81) | 1.71 (1.61,1.81) | 1.71 (1.61,1.81) | 1.71 (1.61,1.81) | 1.71 (1.61,1.81) | 1.71 (1.61,1.81) |        |
| Triglyceride | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) |        |
| HDL         | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) |        |
| TG           | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) |        |
| LDL         | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) |        |
| Cholesterol | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) | 1.29 (1.27,1.31) |        |

Weekday variation in triglyceride concentrations

Table 3. Weekday variation for TGs in different strata of the population
| Week   | Monday Mean (95% CI) | Tuesday Mean (95% CI) | Wednesday Mean (95% CI) | Thursday Mean (95% CI) | Friday Mean (95% CI) | Saturday Mean (95% CI) | Sunday Mean (95% CI) | <Diff (P)> |
|--------|----------------------|-----------------------|-------------------------|------------------------|---------------------|-----------------------|-----------------------|----------------------|
| Year 1 | 1.61 (1.51;1.71)     | 1.55 (1.51;1.60)     | 1.59 (1.55;1.63)        | 1.60 (1.56;1.64)      | 1.61 (1.58;1.65)   | 1.58 (1.54;1.61)      | 1.57 (1.53;1.60)     | <0.0001  |
| Year 2 | 1.64 (1.54;1.74)     | 1.62 (1.58;1.67)     | 1.67 (1.63;1.71)        | 1.68 (1.64;1.72)      | 1.69 (1.66;1.73)   | 1.67 (1.64;1.70)      | 1.66 (1.63;1.70)     | <0.0001  |
| Year 3 | 1.68 (1.58;1.78)     | 1.66 (1.62;1.71)     | 1.71 (1.67;1.76)        | 1.72 (1.68;1.74)      | 1.73 (1.69;1.76)   | 1.71 (1.66;1.67)      | 1.70 (1.65;1.70)     | <0.0001  |

Data are presented as mean ± 95% CI per day using a linear mixed model adjusted for gender, age group (5-year intervals), fasting status (fasting, nonfasting), hospitals, setting (out-patient, in-patient), and subject as random effect. The mean and 95% CI are expressed as mmol/l. TG: 1 mmol/l is equivalent to 88.57 mg/dl. Using pairwise comparisons, the difference between Monday and Friday indicates a higher value on Monday compared with Friday.
therefore be reasonably generalizable to the entire population in Denmark due to the rather homogenous lifestyle during weekends and non-weekend days among the 5.5 million Danes. Potential deviations from this weekday pattern in other countries around the world may be helpful for identification of its causes.

A limitation of the study is that the study relied solely on samples collected from patients. Certain subgroups, such as the children below 1 year of age cannot be generalized to the general populations, as these children most likely suffer from severe illness. Another limiting factor is the scarcity of patient characteristics, lacking information about the reason for TG measurement, educational concentration, ethnicity, alcohol consumption, dietary intake, and PA; residual confounding may persist. Moreover, based on the observational nature of the data and the lack of recorded exposures in the present study, no causal relationship can be established. Rather, this comprehensive analytic exploration of a large amount of data and the ensuing discussion of key findings are intended to serve as a starting point to generate hypotheses for future research on this topic. An important and initial question is to what extent the variation in TG during weekdays occurs also in other countries or if it is caused by a specific lifestyle in Denmark during the weekends. However, as TG is a component of the metabolic syndrome and a prevalent outcome measurement used in various areas of research, careful planning of future studies may help to avoid undesirable differences attributed to the day and the time of the day the measurement was obtained.

In conclusion, TG concentrations were higher after the weekend and gradually improved during the weekdays. This variation was consistent across all strata, persisted after multiple adjustments, and was likely not attributed to hemodilution or alcohol consumption. We suggest that, in addition to increased concentration of TG that lasts for a few hours after food intake during the day, alterations in food intake and amounts of PA during the weekend increase TG concentrations to a smaller extent, which tracks into the week. A potential difference in research results due to weekday variation may carry implications for public health and may have major implications for future research practice.

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