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# Trends in overweight, obesity and blood pressure among Israeli working adults—implications for public health

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**Backgrounds:** Reports from the last decade suggest an epidemic of overweight and obesity in Western countries. Since obesity has been associated with increased blood pressure, we aimed to describe the secular trends in overweight and obesity and blood pressure among Israeli working adults. **Methods:** Two cross-sectional studies were conducted in the setting of the Civil Servant Registry, Tel-Aviv District Health Office, Ministry of Health, Israel, including 1949 adults aged 17–69 years, who entered the Israeli civil service in 1993 and 2002. **Results:** Compared with other reports, the overall prevalence rate (32.2%) of overweight and obesity was relatively low in our study population, however, an increase of 34% in the odds of being overweight or obese was noted during the study period (adjusted odds ratio: 1.34, 95% CI: 1.09–1.65). Despite this increase, the adjusted mean systolic blood pressure significantly fell from 119.3 (18.2) to 117.0 (14.3) mmHg ($P<0.001$) during the 10-year period, and the respective mean diastolic blood pressure declined from 74.5 (9.0) mmHg to 73.2 (9.8) mmHg ($P<0.001$). **Conclusion:** Israel joined the universal trend of increase in overweight and obesity. This study demonstrated a concomitant decline in blood pressure that could not be attributed to antihypertensive treatment. The decrease in blood pressure could partially explain the decrease in cardiovascular morbidity and mortality seen in Israel.

**Keywords:** adult, blood pressure, cross-sectional studies, obesity, overweight

A considerable increase in the prevalence of overweight and obesity has been noted in several Western countries over the past decade,[1–4] suggesting a global epidemic with public health implications. This alarming increase has caused the US task force on community preventive services to publish recommendations of strategies for preventing and controlling overweight and obesity in school and worksite settings.[5]

The last report on secular trends in body mass index (BMI) in Israel was conducted between the years 1963 and 1987 among male workers;[6] this study showed an increase in mean BMI towards a prevalence of overweight and obesity of around 31%. A more recent report, based on a household survey, demonstrated a prevalence rate of 62.2% among adults aged 25–64 years,[7] similar to the prevalence rate reported in the USA.[2]

Obesity has been associated with increased blood pressure[8] and BMI and blood pressure were shown to be positively correlated;[9] Therefore, it is reasonable to assume that where secular trends show an increase in BMI a concomitant increase in blood pressure will also be evident. Indeed, in the setting of the NHANES studies, the decrease in prevalence of hypertension noticed since the 1960s, levelled-off since 1988, with the increase in BMI.[10]

The objective of this study was to describe secular trends in overweight, obesity and blood pressure in a population of working Israeli adults during a recent 10-year time span and to discuss the possible public health implications.

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## Methods

This study was conducted in the Civil Servant Registry of the Tel-Aviv Health District Office which oversees the medical screening of all new civil service employees in Israel's two largest districts—the Tel-Aviv and the Central districts (population of more than 2.5 million inhabitants). Our study population consisted of two samples garnered from the civil servant health status screening files from the years 1993 and 2002.

These screening files include socio-demographic data (age, sex, position in the civil service), medical history, anthropometric and blood pressure measurements, medical examinations and laboratory test results of new employees prior to entering the Israeli civil service. Interviews, measurements and examinations are either performed directly or approved by occupational physicians and reported on structured forms. A civil servant that is found to have a health condition acknowledged by Israel's social security criteria lists as a disability is recognized as 'health impaired'.

We sampled every 10th file in the registry from those 2 years. Files of health-impaired individuals were archived separately and therefore sampled separately. The proportion of health-impaired individuals in our study (about 25%) was kept similar to their proportion in the civil servant population. Altogether we sampled 1016 files from 1993 and 933 files from 2002.

Data on BMI was 98% complete while data on blood pressure was 99% complete.

### *Data analysis*

BMI was calculated as the ratio of weight (kg)/height ($m^2$). Overweight was defined as $25 \leq BMI < 30 kg/m^2$ and obesity was defined as $BMI \geq 30 kg/m^2$ based on WHO guidelines.[11] Pulse pressure (PP) was computed as the difference between systolic blood pressure (SBP) and diastolic blood pressure (DBP). Mean arterial blood pressure (MAP) was computed as [(1/3SBP) + (2/3DBP)].

Univariate analysis compared the prevalence of overweight and obesity and the mean BMI and blood pressure measures between the two years by strata of origin, age, sex and health status. Categorical variables were compared using the $\chi^2$-test and continuous variables were compared using ANOVA or the Student's *t*-test. Logistic regression was used to calculate the odds ratio (OR) for overweight and obesity in 2002 as compared with 1993, controlling for the study covariates. Multiple linear regression was used to compare mean SBP and DBP between the 2 years, after controlling for study covariates. All analyses were conducted using SPSS statistical package version 12.0. A two-tailed *P*-value <0.05 was considered statistically significant.

## Results

### Study population

The study population included 1949 participants with a mean age of 34.3 (SD 9.3) years. There were no differences in age and country of birth between 1993 and 2002. The majority of workers were women, but in 2002 the proportion of males was significantly higher than in 1993 (38 versus 32%, respectively, $P = 0.005$).

### Overweight and obesity

Among all study participants, mean BMI was 23.8 (SD 3.9) kg/m$^2$ and it was positively correlated with age ($r = 0.265$, $P < 0.01$). BMI was higher in men as compared with women [24.86 (SD 3.28) versus 23.33 (SD 3.98) kg/m$^2$, respectively, $P < 0.001$]. Across all age groups, men had a higher prevalence of overweight and obesity than women (43.7 versus 25.8%, men versus women respectively, $P < 0.001$).

Over the study period, an increase was noted in mean BMI of civil service employees, from 23.49 (SD 3.56) in 1993 to 24.25 (SD 4.05) in 2002 ($P < 0.001$). In 1993, 23.3% of subjects were overweight and 5.3% were obese as compared with 27.3% overweight and 8.3% obese in 2002 ($P = 0.002$). The crude OR for being either overweight or obese in 2002 versus 1993 was 1.36 [95% confidence interval (CI): 1.13–1.66].

Stratifying by country of birth, significant increases in the prevalence of overweight and obesity were noted between 1993 and 2002 only among individuals born either in Israel or in Eastern-European countries (Israel: 23.1 versus 32.8%, respectively, $P = 0.001$; Eastern Europe: 39.6 versus 45.7%, respectively, $P = 0.005$). Among Eastern European born individuals, mean BMI was higher in those who immigrated before 1985 as compared with those who immigrated after 1985 [25.4 (SD 4.3) versus 24.5 (SD 3.6) kg/m$^2$, $P = 0.036$]; however, in a multivariate analysis of the association of BMI with age, origin, gender and study period, year of immigration was unrelated to BMI.

*Table 1* presents the OR for overweight and obesity according to the study covariates. Adjustments for age, gender, origin and health status did not materially alter the crude association between overweight and year (adjusted OR: 1.34, 95% CI: 1.09–1.65). According to the logistic models, risk factors for overweight and obesity included male gender (adjusted OR: 2.31, 95% CI: 1.86–2.85), Eastern-European origin (adjusted OR: 1.5, 95% CI: 1.17–1.92) and health impairment (adjusted OR: 1.55, 95% CI: 1.23–1.95). Asian-African origin had a protective effect (adjusted OR: 0.53, 95% CI: 0.32–0.87). Further adjustments for socio-economic status according to type of position in the civil service did not alter the results.

### Blood pressure

Mean SBP and DBP for the entire study population were 118 (SD 14) mmHg and 73.9 (SD 8.7) mmHg, respectively. Mean SBP and DBP were significantly higher among men as compared with women, whereas mean heart rates (HR) were higher among women [men versus women: SBP: 124 (SD 14.1) versus 115 (SD 16.9) mmHg, $P < 0.001$; DBP: 76.5 (SD 8.6) versus 72.4 (SD 8.7) mmHg, $P < 0.001$, HR: 73.8 (SD 10.1) versus 75.6 (SD 8.8) beats per minute, $P < 0.001$]. These gender differences were consistent both in 1993 and 2002 (*table 2*).

Overall SBP and DBP were highly correlated ($r = 0.55$, $P < 0.001$). Both SBP and DBP were similarly correlated with BMI, with correlation coefficients of 0.24 ($P < 0.001$) and 0.27 ($P < 0.001$), respectively. SBP and DBP were correlated with HR, having the same correlation coefficient of 0.11 (both $P < 0.001$).

A decreasing trend in SBP over the study period was noted [119 (SD 18.2) versus 117 (SD 14.3) mmHg, 1993 versus 2002, respectively, $P = 0.002$]. A similar trend was noticed for DBP and HR comparing 1993 with 2002 [DBP: 74.5 (SD 9.0) versus 73.2 (SD 8.7) mmHg, respectively, $P = 0.001$; HR: 75.5 (SD 8.8) versus 74.5 (SD 9.8) beats per minute, respectively, $P = 0.018$]. MAP decreased accordingly from 89.4 (SD 9.5) mmHg to 87.8 (SD 9.4) mmHg ($P < 0.001$); however, there was no change in PP over the study period, having means of 44.6 (SD 10.9) mmHg in 1993 and 44.0 (SD 10.1) mmHg in 2002 ($P = 0.27$).

**Table 1** The ORs for being overweight and obese (BMI≥25) versus normal and lean (BMI<25) by study variables, according to the logistic regression

| | *n* BMI<25 | *n* BMI≥25 | Crude OR | 95% CI | Age-adjusted OR | 95% CI | Adjusted OR* | 95% CI |
|---|---|---|---|---|---|---|---|---|
| Year | | | | | | | | |
| 2002 | 597 | 329 | **1.37** | 1.13–1.66 | **1.35** | 1.10–1.64 | **1.34** | 1.09, 1.65 |
| 1993 | 701 | 283 | **ref** | – | **ref** | – | **ref** | – |
| Gender | | | | | | | | |
| Male | 371 | 288 | **2.22** | 1.82–2.70 | **2.19** | 1.78–2.69 | **2.31** | 1.86, 2.85 |
| Female | 925 | 324 | **ref** | – | **ref** | – | **ref** | – |
| Country of birth (Origin) | | | | | | | | |
| Asia-Africa | 78 | 27 | **0.89** | 0.56–1.40 | **0.54** | 0.33–0.87 | **0.53** | 0.32, 0.87 |
| Eastern Europe | 263 | 193 | **1.89** | 1.51–2.36 | **1.38** | 1.08–1.75 | **1.50** | 1.17, 1.92 |
| W. Europe and America | 60 | 34 | **1.46** | 0.94–2.26 | **1.17** | 0.75–1.85 | **1.25** | 0.78, 1.98 |
| Israel | 871 | 339 | **ref** | – | **ref** | – | **ref** | – |
| Health status | | | | | | | | |
| Impaired | 293 | 198 | **1.64** | 1.32–2.03 | **1.44** | 1.15–1.80 | **1.55** | 1.23, 1.95 |
| Healthy | 1005 | 414 | **ref** | – | **ref** | – | **ref** | – |

Reference categories: year 1993, female gender, individuals born in Israel and no health impairment
*Adjusted, where suitable, for age, gender, origin, health status and year
OR: odds ratio; CI: confidence interval

**Table 2** Mean SBP, DBP, HR, MAP and PP by the study covariates

| | SBP | | | DBP | | | MAP | | | PP | | | HR | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1993 | 2002 | *P* | 1993 | 2002 | *P* | 1993 | 2002 | *P* | 1993 | 2002 | *P* | 1993 | 2002 | *P* |
| Male | 125.8 | 122.3 | 0.001 | 78.1 | 75.0 | <0.001 | 94.00 | 90.81 | <0.001 | 47.61 | 47.30 | 0.72 | 74.1 | 73.6 | 0.56 |
| Female | 116.1 | 114.1 | 0.007 | 72.8 | 72.0 | 0.123 | 87.34 | 86.06 | 0.013 | 43.15 | 42.06 | 0.049 | 76.2 | 75.0 | 0.021 |
| BMI<25 | 116.8 | 114.6 | 0.003 | 73.2 | 71.8 | 0.003 | 87.76 | 86.08 | 0.001 | 43.54 | 42.83 | 0.22 | 75.2 | 74.4 | 0.11 |
| 25≤BMI<30 | 124.9 | 121.3 | 0.003 | 77.4 | 75.1 | 0.006 | 93.39 | 90.50 | 0.001 | 47.26 | 46.22 | 0.28 | 75.5 | 74.1 | 0.092 |
| BMI≥30 | 126.7 | 123.5 | 0.20 | 78.5 | 77.6 | 0.59 | 94.59 | 92.90 | 0.35 | 48.17 | 45.95 | 0.25 | 79.2 | 76.9 | 0.12 |
| Healthy | 118.2 | 116.6 | 0.034 | 74.1 | 72.4 | <0.001 | 88.81 | 87.18 | 0.001 | 43.97 | 44.22 | 0.65 | 75.2 | 74.1 | 0.023 |
| Health impaired | 122.1 | 118.7 | 0.013 | 75.6 | 75.3 | 0.72 | 91.26 | 89.79 | 0.006 | 46.25 | 43.43 | 0.10 | 76.2 | 75.6 | 0.42 |
| Total | 119 | 117 | 0.002 | 74.5 | 73.2 | 0.001 | 89.4 | 87.8 | <0.001 | 44.6 | 44.0 | 0.27 | 75.5 | 74.5 | 0.018 |

SBP: systolic blood pressure; DBP: diastolic blood pressure; MAP: mean arterial pressure; PP: pulse pressure; HR: heart rate

**Table 3** Age, gender, origin, BMI, health status and heart rate adjusted means of SBP, DBP, PP and MAP in 1993 and 2002

| | 1993 | | 2002 | | *P*-value |
|---|---|---|---|---|---|
| | Mean | 95% CI | Mean | 95% CI | |
| SBP | 127 | (125–129) | 125 | (123–127) | <0.001 |
| DBP | 79.0 | (77.8–80.1) | 77.4 | (76.2–78.6) | <0.001 |
| PP | 48.5 | (47.0–50.0) | 47.8 | (46.2–49.2) | 0.131 |
| MAP | 95.1 | (93.9–96.4) | 93.4 | (92.1–94.6) | <0.001 |

MAP: mean arterial pressure; CI: confidence interval

After controlling for age, gender, origin, BMI and heart rate, the adjusted means of systolic, diastolic and MAP were about 2mmHg lower in 2002 than in 1993 (*table 3*).

## Discussion

In this study, we documented an increase in overweight and obesity and a decrease in SBP and DBP over a 10-year period in a working adult population. Our findings of a decrease in SBP and DBP in the Israeli population are supported by a study from Sweden[12] that demonstrated decreases in blood pressure among 50-year-old adults between 1963 and 1993. However, studies from the USA, Finland and Denmark demonstrated declines in SBP and DBP that levelled-off during the 1990s,[10,13,14] and data from the UK indicated significant increases in SBP and DBP between 1989 and 1999, irrespective of ethnicity.[15]

The decrease in blood pressure found in our study cannot be attributed to antihypertensive treatments, since this decline was noted among healthy, untreated adults. This decrease in blood pressure continues a trend described in previous reports from Israel between 1963 and 1987.[6,16] *Table 4* presents mean blood pressure by year according to these different studies conducted in Israel. The consistent decrease in blood pressure over the years supports our findings. In their report, Gerber *et al.*[16] described a decrease in coronary heart disease mortality despite a significant increase in BMI. The authors attributed this decline to the decrease in SBP. In view of the decreased mean blood pressure among untreated adults we assume a lower incidence of hypertension that is not related to antihypertensive treatments, and we further hypothesize that the decline in mortality from stroke noted in many Western countries as well as in Israel[17] is attributed not only to improved antihypertensive treatments but also to this decreased incidence of hypertension. Supporting our hypothesis, a recent study demonstrated that modest reductions in cardiovascular risk factors (i.e. primary prevention) have twice the effect in reducing cardiovascular morbidity than do improved cardiology treatments.[18] The attributed proportion of this primary prevention should be further evaluated, and in view of the correlation between blood pressure and BMI, might be even greater had we been able to prevent the increase in overweight and obesity

The trend of increased prevalence of overweight and obesity during the study period (from 28.8% in 1993 to 35.6% in 2002) is in agreement with data from other Western countries.[2–4] The overweight and obesity prevalence rates demonstrated in our study (28.8% in 1993 and 35.6% in 2002) were similar to those previously described among Israeli workers[6] and considerably lower than those documented in Sweden, the USA and Greece[2,4,19] as well as those previously reported in Israel in the MABAT survey conducted in 1999–2000.[20] Prevalence rates of overweight and obesity found in the MABAT survey were 65.7% among men and 58.9% in women, aged 25–64 years. The differences between our results and the MABAT findings most probably stem from the difference in the source population of both studies. Our source population consisted of workers, and thus was susceptible to the healthy worker effect, whereas the MABAT's source population consisted of the entire Israeli population. The MABAT's study population included individuals from a random sample, or their neighbours who were at home at the time of visits as proxy, thus suggesting a higher representation of the unemployed than in the general population. Since unemployment has been associated with overweight and obesity,[21] the MABAT's population might be biased towards a higher prevalence of overweight.

The magnitude of increase in the prevalence of overweight and obesity varies greatly between countries, for example, among Swedish men, prevalence rates of overweight and obesity significantly increased from 58.9% in 1990 to 73.1% in 2002; among Swedish women these rates significantly increased from 45.8% to 48.6%.[4] In UK, mean BMI increased among Caucasian men aged 35–60 years from 25.8 in 1989–90 to 26.6 in 1997–99 and among women from 25.0 to 26.0, respectively.[15] In the USA, prevalence rates of obesity significantly increased from 23.3% in 1988–94 to 30.9% in 1998–2000.[2]

The reasons for these secular trends are not clear. The almost universal epidemic of overweight and obesity cannot result from genetic changes, and therefore should be attributed to environmental changes. Whether dietary habits are responsible for the differences in the prevalence of overweight and obesity between origin groups and whether dietary changes are responsible for both the increase in BMI and the concomitant decrease in blood pressure remains to be investigated. Possible dietary changes associated with blood pressure include dietary salt,[22] olive oil and diets rich in proteins rather than carbohydrates.[23–25] It could be that the current average diet of the population studied tends to be of higher caloric content yet of lower salt composition and greater olive oil composition than a decade or more ago. We were not able to assess this hypothesis.

Our study limitations include a possible selection bias that may have been introduced since obesity (BMI ≥ 30), was added to the social security criteria list of health impairment in 2000, and therefore was included in the list in 2002 but not

**Table 4** Reported blood pressure in Israeli studies 1963–2002

| Study (reference) | Study population | | Year | Mean SBP (SD) | Mean DBP (SD) |
|---|---|---|---|---|---|
| | *n* | Mean age (SD) | | | |
| IIHD[6] | 10 048 | 51.7 (10.0) | 1963 | 140.3 (SE = 0.2) | 84.7 (SE = 0.1) |
| IIHD[16,a] | 9699 | 51.2 (6.8) | 1963–68 | 138.1 (21.6) | 86.4 (12) |
| GOH[16] | 1745 | 52.9 (8.3) | 1969–72 | 133.5 (21.1) | 85.8 (11.1) |
| CORDIS[6] | 2237 | 49.2 (4.7) | 1987 | 131.7 (SE = 0.4) | 80.6 (0.2) |
| Present study | 1016 | 34.1 (9.2) | 1993 | 119.3 (18.2) | 74.5 (9.0) |
| Present study | 933 | 34.6 (9.4) | 2002 | 117.0 (14.3) | 73.2 (8.7) |

a: This study population consists of the study population described in ref.[6] that was also examined in 1965 and 1968

in 1993. When examining the data we found that only 52% of obese individuals were recognized as health impaired in 2002. We then tried to estimate this selection bias by restricting our analysis to those with BMI <30 kg/m$^2$ (data not shown) and found a similar increase in BMI over the study period. Furthermore, the inclusion of health impairment in our multivariate analysis did not alter the association of year with overweight/obesity.

As data were not collected for research purposes, we were unable to determine the degree of reliability between different examiners or measurement tools. We inquired in a sample of large and small occupational clinics whether there were changes in instruments and methods of measuring height, weight and blood pressure over the years; no change was reported. Assuming that the many clinics visited used different measurement tools and methods with no systematic change over the years, the magnitude of trends as shown in the results would be non-differentially misclassified, thus biased towards the null.

## Conclusions

Our study suggests a decrease in SBP, DBP and MAP over a 10 year period despite a concomitant increase in BMI. Further research is needed in order to determine the underlying mechanism. The decrease in blood pressure could partially explain the decrease in cardiovascular morbidity and mortality seen in Israel, and might be even greater had we been able to prevent the increase in overweight and obesity.

*Conflicts of interest*: None declared.

## Key points

- This is the first study that describes the secular trends in overweight, obesity and blood pressure in a population of Israeli working adults during the 1990s.
- Our study suggests decreases in SBP, DBP and MAP over a 10 year period despite a concomitant increase in overweight and obesity.
- This decrease in blood pressure continues a trend described in previous studies from Israel in the 1980s and might have implications on cardiovascular morbidity and mortality.

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