The Effect of National Service on Metabolic Control, Weight Status and Incidence of Acute Diabetes Complications in Young Adults with Type 1 Diabetes

Avivit Brener MD[1], Eran Mel MD[1], Shlomit Shalitin MD[1,2], Liora Lazar MD[1,2], Liat de Vries MD[1,2], Ariel Tenenbaum MD[1,2], Tal Oron MD[1], Alon Farfel MD[1], Moshe Phillip MD[1,2] and Yael Lebenthal MD[1,2]

[1]Shafer Institute for Endocrinology and Diabetes, National Center for Childhood Diabetes, Schneider Children's Medical Center of Israel, Petah Tikva, Israel
[2]Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel

ABSTRACT: **Background:** Patients with type 1 diabetes (T1D) are exempt from conscript military service, but some volunteer for national service.

Objectives: To evaluate the effect of national service (military or civil) on metabolic control and incidence of acute diabetes complications in young adults with T1D.

Methods: Clinical and laboratory data of 145 T1D patients were retrieved from medical records. The cohort comprised 76 patients volunteering for national service and 69 non-volunteers. Outcome measures were HbA1c, body mass index-standard deviation scores (BMI-SDS), insulin dosage, and occurrence of severe hypoglycemia or diabetic ketoacidosis (DKA).

Results: Metabolic control was similar in volunteers and non-volunteers: mean HbA1c at various time points was: 7.83 ± 1.52% vs. 8.07% ± 1.63 one year before enlistment age, 7.89 ± 1.36% vs. 7.93 ± 1.42% at enlistment age, 7.81 ± 1.28% vs. 8.00 ± 1.22% one year thereafter, 7.68 ± 0.88% vs. 7.82 ± 1.33% two years thereafter, and 7.62 ± 0.80% vs. 7.79 ± 1.19% three years thereafter. There were no significant changes in HbA1c from baseline throughout follow-up. BMI and insulin requirements were similar and remained unchanged in volunteers and controls: mean BMI-SDS one year before enlistment age was 0.23 ± 0.83 vs. 0.29 ± 0.95, at enlistment age 0.19 ± 0.87 vs. 0.25 ± 0.98, one year thereafter 0.25 ± 0.82 vs. 0.20 ± 0.96, two years thereafter 0.10 ± 0.86 vs. 0.15 ± 0.94, and three years thereafter 0.20 ± 0.87 vs. 0.16 ± 0.96. Mean insulin dose in U/kg/day one year before enlistment age was 0.90 ± 0.23 vs. 0.90 ± 0.37, at enlistment age 0.90 ± 0.28 vs. 0.93 ± 0.33, one year thereafter 0.86 ± 0.24 vs. 0.95 ± 0.33, two years thereafter 0.86 ± 0.21 vs. 0.86 ± 0.29, and three years thereafter 0.87 ± 0.23 vs. 0.86 ± 0.28. There were no episodes of severe hypoglycemia or DKA in either group.

Conclusions: Our data indicate that during voluntary national service young adults with T1D maintain metabolic control similar to that of non-volunteers.

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KEY WORDS: type 1 diabetes (T1D), military service, civil service, metabolic control, weight status

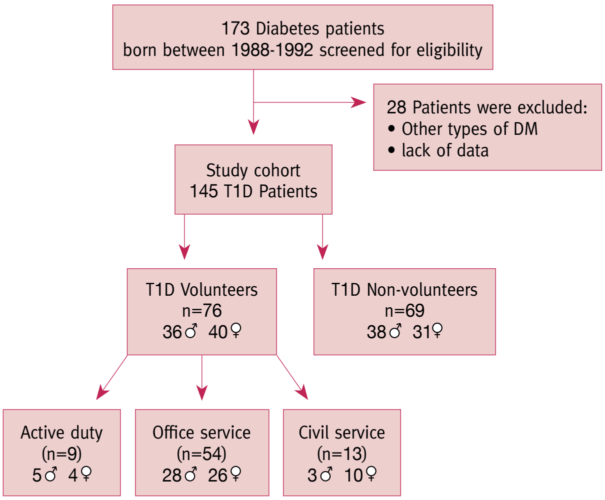
Applicants with type 1 diabetes (T1D) are generally not accepted for military service by most armed forces in the world [1]. The rationale for exempting such patients from military service is the possibility of severe hypoglycemia and subsequent loss of consciousness during stressful situations such as combat conditions [1,2], or diabetic ketoacidosis due to unavailability of insulin. In Israel, young adults with type 1 diabetes are exempt from obligatory army service but may volunteer for civil or military service. Civil service includes volunteer positions at schools, hospitals, nursing homes and with disadvantaged communities, as well as assisting immigrants and teens at risk. In the military the type 1 diabetes volunteers do not serve in combat units but are employed in a variety of non-combative tasks [3]. Many such volunteers do their service relatively close to home and have the option to sleep at home, which is reassuring, especially for those who fear night-time hypoglycemia. Still, the change in daily routine, physical activity and eating habits raises some concern as to whether these might compromise the health status and safety of this population of T1D volunteers.

Only a few studies have reported the experiences of patients with T1D in military service [1,4,5]. The aim of the present study was to evaluate the effect of national service (military or civil) on metabolic control, weight status and incidence of acute diabetes complications in young adults with type 1 diabetes.

PATIENTS AND METHODS

The institutional registry of diabetes patients in our National Center for Childhood Diabetes consecutively records every patient with new-onset diabetes referred to our clinic, registering date of diagnosis, date of birth, and gender. A survey of this institutional registry yielded 173 young adults diagnosed with type 1 diabetes who were born between 1988 and 1992 and followed in our diabetes center. Of these, 28 cases (16%) were excluded from the study due to incomplete data or diagnosis of other types of diabetes, namely, type 2 diabetes, monogenic diabetes (MODY), neonatal diabetes, cystic fibrosis-related

Figure 1. Flowchart of study cohort



diabetes, genetic syndromes associated with diabetes, and drug-induced diabetes.

The cohort of 145 T1D patients was categorized into two groups: the 76 patients who had volunteered for either military or civil service (36 males), and the 69 non-volunteers (38 males) who served as controls [Figure 1]. The study protocol was approved by our Institutional Review Board.

RESEARCH DESIGN

Data were collected from medical visits at five time points: one year prior to enlistment age, at the time of enlistment age, and 1, 2 and 3 years thereafter. The data extracted from the medical file included education and habitual behavior (cigarette smoking, alcohol consumption), in addition to the anthropometric measurements (height, weight, body mass index), date of diagnosis of diabetes, HbA1c levels, episodes of diabetic ketoacidosis (DKA) and severe hypoglycemia, insulin regimen, whether multiple daily injections or continuous subcutaneous insulin infusion, and presence of microvascular complications (retinopathy, nephropathy, or neuropathy).

The routine clinical practice followed for T1D patients in our center has been quarterly clinical visits, with follow-up every 3–6 months for weight (in light clothing using a standard calibrated scale) and height (using a commercial Harpenden-Holtain stadiometer, until final achievement of height). Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. BMI-standard deviation scores (SDS) were calculated according to the recommendations of the Centers for Disease Control and Prevention [6]. The medical team (nurses and physicians) routinely questioned patients about cigarette smoking and alcohol consumption, and self-reported responses were documented in medical files. Regular smoking was defined as smoking at least one cigarette once a week and regular alcohol consumption as drinking at least one alcoholic beverage once a week. Female patients were routinely questioned about their menstrual cycle: whether menses was absent or present and whether the cycle was regular or irregular, as well as their use of oral contraceptives (OC).

HbA1c was routinely tested at 3–6 month intervals. Capillary HbA1c values were determined using an automated immunochemical technique (DCA 2000, Siemens Medical Solutions Diagnostics, Tarrytown, NY, USA); the 95% confidence limits (mean ± 2 SD) were 4.3–5.7%.

DKA events were defined as blood pH < 7.3 with bicarbonate < 15 mEq/L and need for intravenous fluid and insulin infusion. A severe hypoglycemic episode was defined as coma or seizures, or need for glucagon injections or intravenous glucose infusion. Episode frequency was calculated per patient per year. Episodes of severe hypoglycemia and DKA are documented in the patient's medical file at each clinic visit and after each hospitalization or referral to the emergency room for these indications.

Routine screening for microvascular complications was generally initiated in pubertal patients during the first year after diagnosis, with subsequent annual assessment [7]. Screening for microvascular complications included an ophthalmologic examination, testing of urine for albumin secretion, and neurological examination. Retinal examinations consisted of direct ophthalmoscopy. The initial screening test for microalbuminuria was the microalbumin-to-creatinine ratio in a first morning voiding urine specimen; when this ratio was at or above the upper normal limit (0.00–0.03) a 24 hour urine collection was obtained for further testing. Microalbuminuria was defined as a urinary albumin excretion rate of 30–300 mg/24 hours. Bedside neurological assessment using the Neuropathy Disability Score [8] was performed to screen for distal polyneuropathy.

STATISTICAL METHODS

All analyses were carried out using the BMDP program [9] and the results are expressed as mean ± SD or number (percentage). For continuous variables, comparisons between groups were made using one- or two-way analysis of variance (ANOVA) with Bonferroni's adjustment for multiple comparisons. Discrete variables were compared using Pearson's chi-square test or Fisher's exact test, as appropriate. A P value ≤ 0.05 was considered significant.

RESULTS

Of the 145 young adults with type 1 diabetes comprising the study cohort, 76 (52.4%) volunteered for national service. Of these, 54 were employed in office positions in the military, 13 served in civil service and 9 as physical fitness instructors in the military. The mean age at enlistment was 18.7 ± 0.5 years and the mean duration of service was 1.92 ± 0.93 years. Gender distribution revealed a female preponderance (76.9%) in the civil service and a slight male predominance (53.1%) for those serving as physical fitness instructors, with similar gender distribution in office positions (51.9%) ($P = 0.15$). Duration of military service was slightly longer for male than female volunteers (2.13 ± 1.08 years vs. 1.74 ± 0.73 years, $P = 0.067$).

DEMOGRAPHIC DATA

Baseline characteristics at one year prior to enlistment of the T1D volunteers were similar to those of the controls [Table 1]. The percentage of males who chose to volunteer was similar to that of the non-volunteers (47.4% vs. 55.1%, $P = 0.35$). At enlistment age, most of the cohort were high school graduates (97.9%), with a higher percentage of T1D volunteers having achieved a matriculation degree (92.1% vs. 79.7%, respectively, $P = 0.04$).

METABOLIC CONTROL [FIGURE 2]

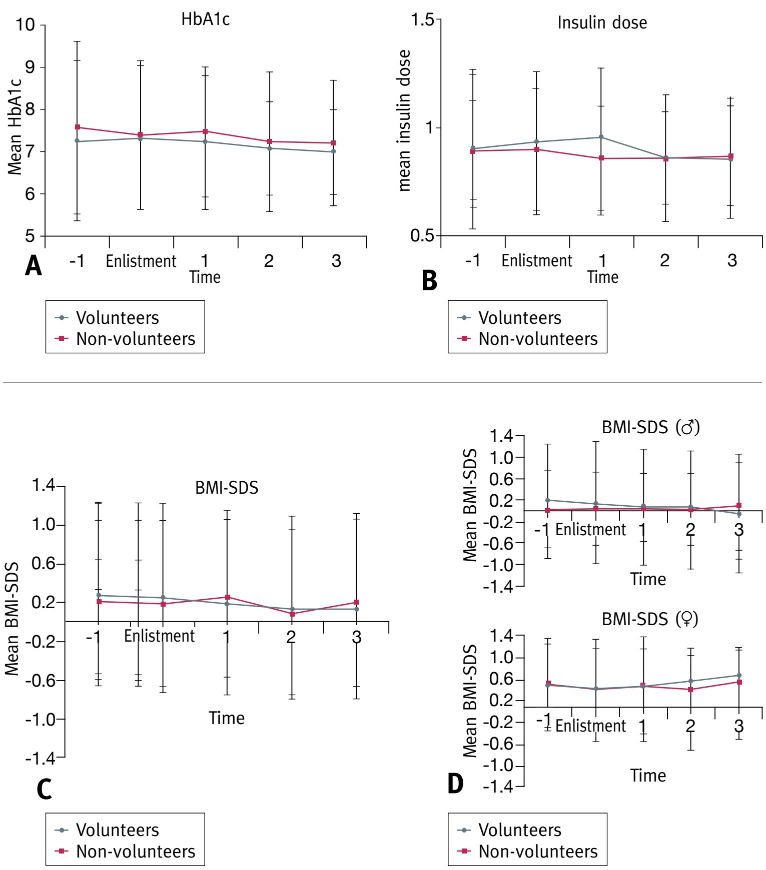
Mean HbA1c of the cohort at one year prior to enlistment age was 7.95 ± 1.57% (63 ± 17 mmol/mol), with no significant difference between the volunteers and the non-volunteers [7.83 ± 1.52% (62 ± 17 mmol/mol) vs. 8.07 ± 1.63% (65 ± 18 mmol/mol), respectively, $P = 0.37$]. Metabolic control was similar in volunteers and non-volunteers at one year prior to enlistment age, at enlistment age, and 1, 2 and 3 years thereafter, with no significant changes from baseline throughout follow-up [Figure 2A]. Mean daily insulin dose at one year prior to enlistment age was 0.90 ± 0.31 units/kg/day. Insulin requirements were similar in the volunteers and non-volunteers at one year prior to enlistment age, at enlistment age, and 1, 2 and 3 years thereafter, with no significant changes from baseline throughout the follow-up [Figure 2B]. Weight status as expressed in BMI-SDS was normal at one year prior to enlistment age (mean BMI-SDS 0.26 ± 0.89), with no significant difference between the volunteers and non-volunteers (0.23 ± 0.83 vs. 0.29 ± 0.95, respectively, $P = 0.68$). Weight status was similar in volunteers and non-volunteers one year prior to enlistment age, at enlistment age, and 1, 2 and 3 years thereafter, with no significant changes from baseline throughout follow-up [Figure 2C]. One year prior to enlistment age, most patients were treated with MDI (61.4%); the mode of use of MDI was similar in the volunteers and non-volunteers throughout.

Metabolic control and insulin requirements were similar in male and female volunteers at one year prior to enlistment [mean HbA1C 7.71 ± 1.46% (61 ± 16 mmol/mol) vs. 7.95 ± 1.59% (63 ± 17 mmol/mol), respectively, $P = 0.99$; mean insulin dose 0.88 ± 0.20 vs. 0.92 ± 0.26 U/kg/day, respectively, $P = 0.48$]. Male volunteers weighed less than female volunteers one year prior to enlistment (mean BMI-SDS 0.04 ± 0.71 vs. 0.43 ± 0.9, respectively, $P = 0.03$) [Figure 2D]. There were no significant changes in HbA1c, BMI-SDS and insulin dosage

Table 1. Comparative analysis between type 1 diabetes national service volunteers and their non-volunteer controls

	National service volunteers (n=76)	Non-volunteer controls (n=69)	*P* value
Males/females, n (%)	36 (47.4)/ 40 (52.6)	38 (55.1)/ 31 (44.9)	0.35
Age at time of enlistment, years	18.8 ± 0.5	18.6 ± 0.4	0.13
Age at diagnosis of diabetes, years	10.7 ± 4.3	11.8 ± 3.9	0.09
Education High school education, n (%) High school matriculation degree, n (%)	 74 (97.4) 70 (92.1)	 68 (98.5) 55 (79.7)	0.04
Coexistent autoimmune diseases Hashimoto disease, n (%) Celiac disease, n (%)	13 (17.1) 8 (10.5) 5 (6.6)	5 (7.2) 3 (4.3) 2 (2.9)	0.16

Figure 2. Metabolic parameters of type 1 diabetes subjects. **[A]** Glycated hemoglobin (HbA1C) (%), **[B]** total daily insulin requirements (units/kg/day), **[C]** body mass index-standard deviation score (BMI-SDS). No significant differences were found between type 1 diabetes volunteers and non-volunteers. No significant changes from baseline throughout follow-up were found in glycemic control, insulin requirements and weight status. **[D]** BMI-SDS of T1D subjects subcategorized by gender. No significant changes from baseline throughout follow-up were found in weight status in both males and females. Data are presented as mean ± SD. Two years after enlistment: 61 volunteers (26 M, 35 F), 56 non-volunteers (33 M, 23 F); 3 years after enlistment: 50 volunteers (25 M, 25 F), 46 non-volunteers (26 M, 20 F).



in both male and female volunteers from one year prior to recruitment throughout follow-up. BMI-SDS, gender and age were not associated with HbA1c in the entire cohort, neither for the volunteers and non-volunteers separately.

DIABETES COMPLICATIONS

- *Short-term complications.* At one year prior to enlistment age the rates of DKA events were similar in the volunteers and non-volunteers (2.6 vs. 0 events per 100 patient/years, P = 0.50), as were the rates of severe hypoglycemia events (5.2 vs. 0 events per 100 patient/years, P = 0.12). Throughout the period from enlistment age to young adulthood there were no reports of DKA events or severe hypoglycemia episodes in either the volunteers or the non-volunteers. Of note were the reports of recurrent hypoglycemia at enlistment age in four volunteers and in two non-volunteers.
- *Microvascular complications.* In young adulthood the prevalence of microvascular diabetes complications was low in both the volunteers and the controls, with no diagnoses of retinopathy or neuropathy. At one year prior to enlistment age microalbuminuria was detected in 5 patients (3.4%) in the cohort: 4 (5.3%) in the volunteer group and 1 (1.4%) in the non-volunteer group; at enlistment age microalbuminuria was found in 5 patients (6.6%) in the volunteer group with no change in the non-volunteer group. The prevalence of microalbuminuria did not significantly change throughout follow-up from one year prior to enlistment age to young adulthood.

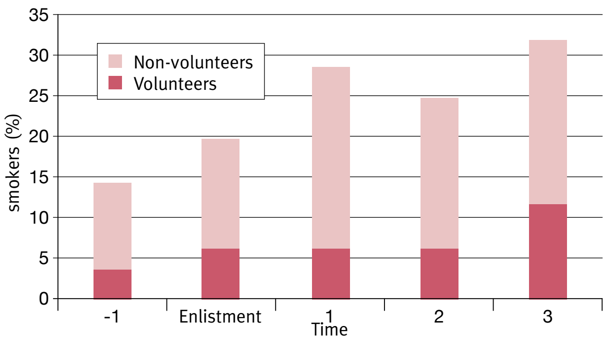
MENSTRUAL CYCLES

At one year prior to enlistment age (mean age 17.7 years) menstrual cycles were reported as regular in the majority of the female cohort, 58/71 (81.7%), while 10/71 (14.1%) reported irregular menstrual cycles, and a few used oral contraceptives (OC), 3/71 (4.2%). These findings were similar in female volunteers and their non-volunteer controls: regular menses 30/40 (75%) and 28/31 (90.3%), irregular menses 8/40 (20%) and 2/31 (6.5%), and OC 2/40 (5%) and 1/31 (3.2%), respectively, P = 0.29. With the progression in age the percentage of females using OC increased to 31.1%, with no significant difference between the female volunteers and the non-volunteer controls.

SMOKING AND ALCOHOL [FIGURE 3]

At one year prior to enlistment age, 6.9% of the study cohort reported that they were smokers and 2.1% (4% of volunteers, 10% of non volunteers) reported that they consumed alcohol on a regular basis; all of the alcohol consumers also smoked. Throughout follow-up the percentage of smokers increased to 15.6% and that of alcohol drinkers to 11.5%, with 7.3% reporting both smoking and alcohol consumption. Self-reported smoking and alcohol consumption was similar in the two groups at all time points assessed.

Figure 3. Prevalence of type 1 diabetes subjects who smoked. No significant differences were found between T1D volunteers and non-volunteers. No significant changes from baseline throughout follow-up were found in percentage of smokers. Two years after enlistment: 61 volunteers, 56 non-volunteers; 3 years after enlistment: 50 volunteers, 46 non-volunteers.



DISCUSSION

In this retrospective comparative clinical study we found that the type 1 diabetes volunteers maintained moderate glycemic control throughout the period of their national service, without altering their weight status or experiencing diabetes-related complications, similar to the age-matched T1D non-volunteer controls.

National service coincides with the stage of life known as emerging adulthood [10]. Young adults with type 1 diabetes who volunteer for service are faced with significant lifestyle changes. They must adapt to a new environment with strict rules and boundaries and with institutional food which is not always suitable for diabetics. Several studies have reported the difficulties that young adults with type 1 diabetes encounter in this period of transition [11-13], although none of these studies dealt with this important aspect of the lives of young Israeli adults. The positive social and psychological implications for young T1D adults who undertake national service include being similar to their healthy peers and functioning successfully in a stressful environment.

The present study clearly demonstrates that the glycemic control of the T1D volunteers was not negatively impacted by their national service. The average glycated hemoglobin in our cohort at the time of enlistment was similar to that of a reported Finnish cohort of male T1D patients who volunteered for service in the military [5]; however, contrary to the Finnish cohort, in our cohort voluntary service did not result in worsening of glycemic control. The fact that the average HbA1c in our cohort was above the treatment targets in adolescence (one year prior to enlistment age) and in young adulthood is in line with studies from the United States [14], Europe [15] and Israel [16], reporting that adolescents and young adults with type 1 diabetes do not attain treatment targets. Yet the average HbA1c of our adolescents and young adults was better than that reported by others [14-16] and was not adversely affected by national service.

It is reassuring that in our cohort national service was not associated with weight gain. This is in contrast to a reported weight gain trend in Israeli male and female soldiers during compulsory service [17]. Of note, however, were the gender disparities in weight status: female volunteers weighed more than male volunteers. It is well established that weight gain is associated with increased risk of coronary heart disease in young adulthood and this risk is escalated in type 1 diabetes patients. A plausible explanation for the lack of weight gain in our cohort could be the nutritional counseling provided by specialized dieticians with expertise in diabetes. Moreover, our multidisciplinary team strongly encourages exercise as an important aspect in the management of diabetes [18]. Although the majority of T1D volunteers serve in sedentary positions, most are stationed near their homes to permit their return after duty, allowing them to make healthy food choices and giving them time for exercise.

National service did not place volunteers at increased risk for acute diabetes complications. The incidence of severe hypoglycemia and DKA episodes in our study cohort was lower than that reported in other population-based studies [19-21]. Leese et al. [19] reported that severe hypoglycemia requiring emergency assistance from health service personnel occurred in 7.1% of type 1 diabetes patients at the rate of 11.5 events per 100 patient-years. Another study of a large U.S. cohort reported severe hypoglycemia events in 6.9% of patients at age 18–26 years, with DKA events occurring in 10.5% during one year [21]. In line with a previous report from our institute, our young adults had a significantly lower percentage of acute diabetes-related complications (severe hypoglycemia and DKA) [22].

National service was not found to be associated with an increased prevalence of smoking. Since it is known that smoking negatively affects type 1 diabetes management and increases the risk for long-term complications [23], it is our policy to advise all our patients not to smoke, although a certain number do. The percentage of our young adult T1D patients who smoked was relatively low (15.6%). This is lower than reported in young Israeli adults (33.8%) [24], and lower than the reported rate in adolescents from some other countries (7–48%) [25].

The fact that in Israel diabetes is not an automatic bar to national service provided us with the opportunity to evaluate the metabolic impact of such service as well as any similarities and differences between volunteers and non-volunteers. In contrast to army conscripts, our studied cohort of T1D volunteers did not switch to military health care but remained under the care of the multidisciplinary diabetes team. It is plausible that this continuity of medical care was a privilege that helped maintain rather than worsen metabolic control during this period of emerging adulthood. Another contributing factor may be an ascertainment bias stemming from the fact that the more motivated young adults decide to remain under our care, while those less motivated decide to leave our facility.

The limitations of our study should be noted. Since this was a retrospective study any lack of information could not be compensated. Since some parameters were dependent on patient self-report, the prevalence of events of severe hypoglycemia and habitual behavior (smoking and alcohol consumption) may have been under-reported. Our findings may not be applicable to patients with type 1 diabetes in general, since the patients reported here volunteered for service which did not include active combat duty.

Our data indicate that young adults with T1D undertaking national service can maintain metabolic control similar to that of those who choose not to volunteer, without significant changes in weight or increase in acute diabetes complications. These achievements may perhaps be attributed to the continuity of care provided for our young emerging type 1 diabetes adults in a familiar setting with the same multidisciplinary team that they know and trust.

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Correspondence:
Dr. Y. Lebenthal
Shafer Institute for Endocrinology and Diabetes, National Center for Childhood Diabetes, Schneider Children's Medical Center of Israel, Petah Tikva 49202, Israel
Phone: (972-3) 925-3747
Fax: (972-3) 925-53836
email: yael.lebenthal@gmail.com

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