HEMATOLOGICAL PROFILE OF FEMALE SOLDIERS UNDER DIFFERENT TASKS AND ENVIRONMENTAL CONDITIONS

Yanovich R.[1], Evans RK.[2], Merkel D.[1], Baum I.[1], Erlich T.[1], and Moran, DS.[1]

[1]Heller Institute of Medical Research Sheba Medical Centre, Tel-Hashomer, ISRAEL;

[2]US Army Research Institute of Environmental Medicine, Kansas St., Natick, MA, USA

Contact person: ranovich@sheba.health.gov.il

INTRODUCTION

The number of females engaged in military duties in the Israeli Defense Forces (IDF), particularly within the combat professions, has steadily increased over the past 60 years. Therefore, it has become increasingly important to determine if women have specific sex-related needs that should be addressed (i.e. separate living quarters and/or the need for adaptive equipment). Potential professions for females range from "in-office" and non environmental-strenuous positions, to field and strenuous surroundings [1]. Moreover, it is well known that hematological values differ among ages, gender, place of residence (i.e. altitude above sea level) and physiological conditions [2]. For example, anemia is determined as a state of hemoglobin deficiency of <12g/dl for females and <14g/dl for males. However, what happens to the initial hematological values as a result of shifting from one environmental outline to another, and under different tasks, has not yet been studied.

The purpose of this study was to describe the hematological profile of Israeli female soldiers from two different units: a) an integrated combat unit and b) a home-front professions unit. Measures were taken before and after basic training (BT), and one year after the end of BT. The latter was in order to examine whether hematological parameters considerably changed under different tasks and environmental conditions.

METHODS

We implemented a 16-month surveillance of female combatants from the 'Karakal' unit (FK) (an integrated combat battalion (strenuous profession) who underwent their BT and their entire military service in desert-climate conditions), and female recruits who registered for medic and dental assistance courses (non-strenuous profession) in the medical corps (FC), and who were exposed to Mediterranean climate conditions throughout their military service. The study focused on the subjects during their military service at three time periods: recruitment to BT (month 0), the end of BT (month 4), and a year after the BT (month 16). Blood samples were collected at each phase and the following components were measured: hemoglobin, iron, transferrin, transferrin saturation, ferritin, and Vitamin B12. A monthly follow-up was maintained to monitor the physical fitness program of each group, their physical fitness levels, and the environmental conditions where they were located. This study was part of a larger study

assessing health status of female combatants of the IDF during BT [3, 4]. This study was approved by the Human Use Committees of the IDF Medical Corps and the US Army Research Institute of Environmental Medicine and all the participants gave their free and informed voluntary consent.

RESULTS

A total of 23 FK and 19 FC (out of 222 and 121 who consented at baseline, respectively) were present for all data collection points. There were no significant differences in anthropometric parameters between the two groups at any time point. Both groups exhibited a significant increase in body mass during the first 4 months of training, and a decrease in % body fat from months 4 to 16 (Table 1).

Table 1: Anthropometric variables (mean±SD) of FK and FC groups throughout the study.

Group	**FK** (N=23)			**FC** (N=19)		
Month	**0**	**4**	**16**	**0**	**4**	**16**
Height (cm)	165±1.5			161±1.7		
Weight (kg)	*65±2.4	66.7±2.2	66.3±2.5	*61.5±2.6	62.5±2.5	63.0±3.6
Fat (%)	*33.5±1	$^{\#}$31.9±0.9	†27.7±1.2	*30.7±1.2	$^{\#}$32.2±1.3	29.1±1.0
BMI ($kg \cdot m^{-2}$)	*23.8±0.7	24.3±0.6	24.3±0.7	*23.5±0.7	24.1±0.7	24.1±0.8

* denotes significant differences ($p<0.05$) between month 0 and month 4
$^{\#}$ denotes significant differences ($p<0.05$) between month 4 and month 16
† denotes significant differences ($p<0.05$) between month 0 and month 16

Environment: The FK group was trained and deployed in the southern part of Israel, characterized as desert climate with the average temperatures varying from 37ºC (June-August) to 14ºC (December-February), while the FC group was trained and served in the central parts of Israel characterized as Mediterranean climate with the average temperatures ranging from 28ºC (June-August) to 10ºC (December-February).

Baseline (0 mos): At the beginning of BT we identified a large number of anemic female soldiers (Hgb<12g/dl) in both groups (17.4% and 21.1% from the FK and FC groups, respectively). Moreover, 65.2% of FK and 57.9% of FC were iron deficient (transferrin saturation <16% and/or ferritin <12ng/ml). 4.3% of the FK presented with vitamin B12 deficiency (<150 pg/ml), and 10.5% of the FC with low folate (<2.4 ng/mL) (Table 2).

Basic Training (0 – 4 mos): During the BT period the % of soldiers with iron deficiency increased in both the FK (65.2 to 78.3%) and FC (57.9 to 68.4%), however the percent of those with anemia decreased in the FK group (17.4 to 8.7%). The percent of individuals

with Vitamin B deficiency rose in the FK group only (4.3 to 13%), while the folate deficiency noted in the FC group began to decrease (10.5 to 5.3%) (Table 2).

Table 2: Percent of female soldiers with hematological deficiency among the FK (N=23) and FC (N=19) groups over a 16-month period of military training

Month	Group	Anemia (%)	ID (%)	LTS (%)	LF (%)	LVB (%)	LF (%)
0	FK	17.4	65.2	56.5	30.4	4.3	0
	FC	21.1	57.9	26.3	47.4	0	10.5
4	FK	8.7	78.3	65.2	56.5	13	0.0
	FC	21.1	68.4	36.8	63.2	0	5.3
16	FK	0	47.8	21.7	34.8	21.7	0
	FC	10.5	63.2	42.1	52.6	0	0

ID- Iron Deficiency; **LTS**- Low Transferrin saturation; **LF**- Low Ferritin; **LVB**- Low Vitamin B_{12}; **LF**- Low Folate.

Study Period (0 – 16 mos): At the end of the study period the anemia had resolved for all soldiers in the FK group, and had decreased from 21.1 to 10.5% in the FC. The % of soldiers with iron deficiency decreased in the FK (65.2 to 47.8%), and was attributed to a decrease in the number of individuals with low transferrin saturation rather than low ferritin. Interestingly, however, there was an increase in the number of individuals with iron deficiency in the control group (57.9 to 63.2%), which was related to an increase in the % of individuals with low transferrin saturation and ferritin. Moreover, the vitamin B12 deficiency that was observed among FK group gradually increased from 4.3% to 21.7%, while folate deficiency in the FC group resolved completely (Table 2).

When analyzing the mean hematological values (Table 3) we observed that the FK group subjects' hemoglobin level increased by 6.3% ($p<0.05$). Even though during BT the mean transferrin saturation, iron and ferritin values decreased by 10.5%, 9.4% ($p<0.05$) and 17.2% ($p<0.05$) in the FK group, respectively, an opposite tendency was observed a year after BT, with an increase of 69.8% ($p<0.05$) in transferrin saturation, 52.8% ($p<0.05$) in ferritin and 63.3% ($p<0.05$) in iron. Conversely, the 16 mo values for the FC group exhibited a decrease in transferrin saturation (16.5%) and iron (21.8%) values ($p<0.05$).

Table 3: Hematological mean values among the FK (N=23) and FC (N=19) groups over a 16-month period of military training

Group	Variable	Month		
		0	4	16
FK	Hgb	12.6±0.2	[#]12.8±0.1	[†]13.4±0.2
FC	(g/dl)	12.5±0.2	12.8±0.3	12.9 ± 0.2
FK	Iron	60.4 ± 8.4	[#]54.7 ± 6.4	[†]89.0 ± 7.2
FC	(μg/dl)	80.3 ± 9.5	[J]85.3 ± 11.5	[J]66.7 ± 6.5
FK	Transferrin	350 ± 13	350 ± 10	336 ± 12
FC	(mg/dl)	[*]356 ± 14	365 ± 13	351 ± 16
FK	Transferrin	18.1 ± 2.3	[#]16.2 ± 1.9	[†]27.5 ± 2.4
FC	saturation (%)	24.0 ± 2.6	[J]24.3 ± 2.5	[J]20.3 ± 2.5
FK	Ferritin	[*]15.1 ± 1.2	[#]12.5 ± 1.2	19.1 ± 2.7
FC	(ng/ml)	17.2 ± 3.4	13.4 ± 2.6	12.7 ± 7.5
FK	Folate	7.8 ± 0.7	8.2 ± 0.8	8.4 ± 0.8
FC	(ng/ml)	[*]6.6 ± 0.8	8.1 ± 0.9	7.9 ± 1.1
FK	Vit. B12	[*]323 ± 31	[#]361 ± 18	325 ± 36
FC	(pg/ml)	[*]266± 27	369± 32	337± 31

[J] denotes significant differences ($p<0.05$) between groups
[*] denotes significant differences ($p<0.05$) between month 0 and month 4
[#] denotes significant differences ($p<0.05$) between month 4 and month 16
[†] denotes significant differences ($p<0.05$) between month 0 and month 16

CONCLUSIONS

The significant changes observed in hematological parameters were attributed to the subjects' lifestyle during their military service. Of particular note, however, a high frequency of iron deficiency was found among anemic female recruits on the recruitment day, which was possibly related to excessive iron loss during their menstrual cycle, insufficient nutrition dietary and eating habits prior to enrollment, or both. Most hematological parameters were enhanced during military service, suggesting that the military dietary with intensive medical supervision can improve basic low hematological levels. However, it was also found that the BT environment, which inherently exposes soldiers to increased stress and intense physical activity, negatively influenced some hematological parameters. This finding was also noted in a previous study where subjects who performed strenuous activity exhibited a high prevalence of iron deficiency and anemia [5]. Though there were differences in deployment environments between the two

groups (i.e. deployment location, profession/physical training, and living conditions), and also similarities (i.e. dietary choices) the influence of these factors on the observed hematological deficiencies remains elusive, and warrants further investigation.

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