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SEX-SPECIFIC BODY COMPOSITION CHANGES AFTER A PILOT MULTIDISCIPLINARY LIFESTYLE INTERVENTION IN ACTIVE-DUTY HUNGARIAN DEFENCE FORCES PERSONNEL

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Highlights

- A multidimensional approach improved outcome interpretation.
- Similar baselines led to sex-specific intervention responses.
- Women showed stronger eating control despite smaller body changes.
- Men showed greater fat loss and muscle gain than women.

Abstract

Background: To compare sex-specific body composition changes after a structured lifestyle intervention in Hungarian Defence Forces (HDF) personnel and to describe baseline dietary, behavioral, and psychological profiles. **Material and Methods:** This quasi-experimental pilot study included 40 active-duty participants (21 men, 19 women), aged 24–55 years, enrolled in an ongoing HDF lifestyle program. The 6-month intervention integrated individualized dietary counselling, supervised physical training 3 times weekly, and weekly cognitive-behavioral group sessions. Body composition was assessed at baseline (D0) and after 6 months (D1). Psychological, behavioral, and physical activity variables were assessed at baseline only as profile measures. **Results:** At baseline, age and body mass index (BMI) did not differ significantly between sexes. Men had higher body weight, skeletal muscle mass, visceral fat, and phase angle, whereas women had higher body fat percentage. In both sexes, body weight, BMI, and body fat percentage decreased significantly over 6 months. In men, body weight decreased by mean±standard deviation (M±SD) 9.25±11.68 kg ($p = 0.001$), BMI by M±SD 2.73±2.97 kg/m² ($p = 0.007$), body fat percentage by M±SD 3.77±4.94 percentage points (pp) ($p = 0.011$), and skeletal muscle mass increased by M±SD 1.70±3.58 kg ($p = 0.029$). In women, body weight decreased by M±SD 5.79±5.88 kg ($p = 0.005$), BMI by M±SD 2.27±2.47 kg/m² ($p = 0.024$), and body fat percentage by M±SD 2.66±3.53 pp ($p = 0.030$), whereas skeletal muscle mass increased non-significantly by M±SD 1.13±1.76 kg ($p = 0.063$). Baseline profiles were otherwise similar, except for higher energy intake in men and higher eating behavior scores in women. **Conclusions:** In this pilot sample, participation in a structured multidisciplinary lifestyle intervention was associated with meaningful body composition improvements in both sexes, although response patterns differed. These findings support further evaluation of tailored multidisciplinary lifestyle interventions in military occupational health practice. Med Pr Work Health Saf. 2026;77(3)

Key words: obesity, sex differences, military personnel, body composition, health promotion, lifestyle intervention

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INTRODUCTION

The modern military environment faces increasingly complex health challenges that extend beyond traditional combat-related injuries. In recent decades, lifestyle-related non-communicable diseases – particularly overweight, obesity, and cardiometabolic disorders – have emerged as major threats to the health and operational readiness of active-duty personnel [1–5]. These conditions are associated not only with increased morbidity and long-term healthcare burden but also with reduced physical performance, impaired recovery, higher injury risk, and decreased deployability.

Despite the physically demanding nature of military service, it does not inherently protect against adverse lifestyle patterns. Sedentary behavior during non-operational periods, suboptimal dietary habits, irregular schedules, and chronic psychological stress contribute

substantially to the development of obesity and related metabolic disturbances in military populations [6–8]. As a result, armed forces worldwide, including the Hungarian Defence Forces (HDF), have reported steadily increasing prevalence rates of overweight and obesity among service members.

In response, structured lifestyle intervention programs have been implemented within military health systems, typically integrating physical training, nutritional guidance, and behavioral or psychological support. These multidisciplinary approaches aim not only to reduce body weight but also to improve overall health, functional capacity, and long-term adherence to healthy behaviors. However, the effectiveness of such interventions has often been evaluated using relatively simplistic outcome measures, such as body weight or body mass index (BMI), which may fail to capture meaningful physiological adaptations [9–12].

Increasing attention has therefore been directed toward more comprehensive outcome frameworks. Body composition parameters, including fat mass and skeletal muscle mass, provide a more nuanced understanding of intervention effects than weight alone. Additionally, emerging biomarkers such as phase angle, derived from bioelectrical impedance analysis, have been proposed as indicators of cellular integrity, hydration status, and physiological resilience [13–15]. These multidimensional indicators are particularly relevant in military populations, where functional performance and recovery capacity are critical.

Beyond physiological outcomes, psychological and behavioral factors play a central role in determining the success and sustainability of lifestyle interventions. Variables such as perceived stress, eating behavior, and motivational readiness influence adherence, self-regulation, and long-term maintenance of health-related behaviors [16–18]. In high-demand occupational settings such as the military, these factors may also affect resilience, adaptability, and overall mission effectiveness. Nevertheless, these domains are frequently underrepresented or inconsistently assessed in intervention studies.

An additional limitation of the existing literature is the insufficient consideration of sex-specific responses. Biological, hormonal, metabolic, and psychosocial differences between men and women may lead to distinct adaptation patterns to identical lifestyle interventions [9–12, 17,19–21]. For example, men may experience more rapid increases in lean mass, whereas women may demonstrate more stable behavioral adherence and dietary regulation. Despite these well-documented differences, many studies either do not perform sex-stratified analyses or treat sex merely as a covariate, potentially obscuring meaningful variation in outcomes.

This issue is particularly relevant in military populations, where the proportion of female personnel is steadily increasing. Understanding sex-specific responses to lifestyle interventions is essential for optimizing program design, improving effectiveness, and ensuring equitable health outcomes across service members.

The aim of this pilot study was to compare male and female participants enrolled in a structured lifestyle intervention within the HDF, with a primary focus on sex-specific changes in body composition and a secondary descriptive characterization of baseline dietary, behavioral, and psychological profiles.

MATERIAL AND METHODS

Study design and ethical considerations

This quasi-experimental, non-randomized pre–post intervention study was conducted January 2024–January 2025 within the HDF. The intervention was delivered in an institutional setting under the supervision of qualified professionals, including military medical personnel, registered dietitians, psychologists, and exercise specialists. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and was approved by the relevant institutional authority of the HDF. All participants provided individual written informed consent prior to participation.

Participants

This quasi-experimental pilot study was conducted within an ongoing lifestyle intervention program of the HDF. Active-duty personnel were recommended to participate in the Body Composition Program if they did not meet the required body composition standards. Participation in the program was voluntary. During the study period, 74 personnel participated in the ongoing program; however, only 40 met the criteria for inclusion in the present analysis. Although monthly body composition monitoring was conducted whenever feasible, the present analysis was based only on baseline (D0) and 6-month (D1) values. Across the 6-month period, some participants had 4, 5, or 6 interim measurements, depending on service-related duties, illness, and data completeness. Participants were excluded from the analytical dataset if they were unable to attend the program for 6 consecutive months or if baseline questionnaire data or body composition measurements were incomplete, most commonly due to ser-

vice-related duties, illness, or missing documentation. The final analytical sample comprised 40 active-duty military personnel (21 men and 19 women), aged 24–55 years. Before enrollment, all candidates had undergone their routine annual medical fitness examination, including chest X-ray, laboratory testing, and occupational health assessment. The laboratory evaluation included complete blood count, metabolic, lipid, hepatic, and renal function panels. No medical contraindication to participation in the lifestyle intervention program was identified. Information on service branch affiliation was not recorded in the study database.

Intervention program

The program was based on a multidisciplinary lifestyle modification model integrating nutritional guidance, physical training, and psychological support. Participants received individualized dietary counselling from registered dietitians throughout the 6-month intervention. Nutritional counselling focused on sustainable dietary modification, portion control, healthier food choices, a moderate energy deficit, and adequate protein intake to support fat loss while preserving muscle mass. Participants were not prescribed a single standardized dietary model or fixed macronutrient distribution; instead, dietary recommendations were individualized according to body composition goals, dietary habits, and clinical considerations. Dietary intake was monitored using 3-day food diaries. In the present study, baseline dietary intake data were used to characterize participant profiles, whereas post-intervention food diaries were collected primarily to support counselling and were not included in the present analysis.

Participants attended supervised training sessions 3 times per week, incorporating aerobic conditioning, resistance training, flexibility, and core stability. Training plans were individualized according to baseline fitness level and body composition goals, and progression was adjusted biweekly to ensure appropriate overload and minimize injury risk.

Psychological support was provided through weekly cognitive-behavioral group sessions led by clinical psychologists. Session topics included stress management, goal setting, motivation, resilience, relaxation techniques, and self-monitoring strategies. In the present study, psychological and behavioral questionnaires were used primarily to characterize baseline participant profiles rather than longitudinal psychological outcomes. The integrated intervention aimed to promote sustainable behavioral change across multiple domains rather than focusing on weight loss alone.

Assessment measures

Anthropometric and body composition parameters were assessed at D0 and D1. These included body weight, BMI, body fat percentage, skeletal muscle mass, visceral fat, and phase angle. Body composition measurements were performed using a multifrequency bioelectrical impedance analyzer, InBody 770 (InBody, Seoul, Korea). Visceral fat was additionally assessed using an OMRON BF511 device (OMRON Healthcare, Kyoto, Japan) and expressed in arbitrary units (a.u.). Measurements were performed in underwear and without shoes. Participants were not assessed under standardized fasting conditions, as they continued their routine military duties and daily routines during the intervention. To improve within-subject comparability, follow-up measurements were scheduled at the same part of the day as the baseline assessment whenever possible; participants measured in the morning at baseline were re-measured in the morning, whereas those measured in the afternoon were re-measured in the afternoon. Height was measured in centimetres (cm) using a standard stadiometer, and BMI was calculated as weight in kilograms divided by height in meters squared (kg/m^2). Neck, waist, and hip circumferences were also measured; however, these variables were not included in the present analysis.

Phase angle (PhA) was calculated automatically by the InBody 770 using resistance (R) and reactance (Xc) values at 50 kHz, according to the formula [22,23]:

$$\text{PhA}\ (^\circ) = \arctan(Xc/R) \times (180/\pi) \quad (1)$$

Psychological, behavioral, and physical activity variables were assessed only at D0 and were used to provide descriptive context for participant characteristics rather than longitudinal outcome evaluation. Perceived stress was measured using the 10-item *Perceived Stress Scale*, a widely used and validated instrument for assessing subjective stress levels [13]. Mental toughness was evaluated using the *Mental Toughness Questionnaire*, which assesses key dimensions such as commitment, control, and confidence [24,25]. Eating behavior was assessed using the *Three-Factor Eating Questionnaire*, which evaluates cognitive restraint, uncontrolled eating, and emotional eating [26]. Motivational readiness for behavior change was assessed using constructs based on the transtheoretical model, categorizing participants according to stages of change in both physical activity and nutrition [27,28]. Physical activity levels were assessed using the *Global Physical Activity*

Questionnaire, developed by the World Health Organization, which provides estimates of weekly physical activity expressed in metabolic equivalent task minutes (MET-min/week) [29].

All questionnaires used in the study were validated Hungarian versions of widely applied instruments in health and behavioral research. Higher scores indicated higher levels of the respective constructs. All assessments were carried out by the same trained staff to ensure measurement consistency.

Statistical analysis

Given the pilot nature of the study and the relatively small sample size, analyses were interpreted as exploratory. Data were analyzed using IBM SPSS Statistics, v. 26.0 (IBM Corp., Armonk, NY, USA). Normality was assessed using the Shapiro–Wilk test. Between-sex comparisons were performed using independent-samples t-tests or Mann–Whitney U-tests, depending on distributional assumptions. Within-group pre-post changes in body composition were assessed using paired-samples t-tests or signed-rank tests, as appropriate. Statistical significance was set at $p < 0.05$.

RESULTS

Baseline anthropometric and body composition characteristics are presented in Table 1. There were no significant sex differences in age or BMI at baseline. However, men had significantly higher body weight, skeletal muscle mass, visceral fat, and phase angle, whereas women had significantly higher body fat percentage.

Sex-specific body composition values at baseline and follow-up are presented in Table 2, and the corresponding graphical presentation is shown in Figure 1. Within-group changes over the 6-month intervention period are summarized in Table 3. In both sexes, body weight, BMI, and body fat percentage decreased significantly over the intervention period. In men, the mean±standard deviation (M±SD) reduction in body weight was 9.25±11.68 kg ($p = 0.001$), BMI was reduced by M±SD 2.73±2.97 kg/m² ($p = 0.007$), and body fat percentage by M±SD 3.77±4.94 percentage points (pp) ($p = 0.011$), while skeletal muscle mass increased by M±SD 1.70±3.58 kg ($p = 0.029$). In women, the reduction in body weight was M±SD 5.79±5.88 kg ($p = 0.005$), BMI decreased by M±SD 2.27±2.47 kg/m² ($p = 0.024$), and body fat percentage by M±SD 2.66±3.53 pp ($p = 0.030$), whereas skeletal muscle mass increased non-significantly by M±SD 1.13±1.76 kg ($p = 0.063$). At both baseline and follow-up, men had higher muscle mass, visceral fat, and phase angle, while women had higher body fat percentage. Raw values also indicated decreases in visceral fat in both groups over the intervention period.

Baseline behavioral, psychological, and physical activity characteristics are summarized in Table 1 and illustrated in Figure 2. Psychological, eating behavior, and physical activity variables were assessed only at D0. Men reported significantly higher daily energy intake than women, whereas women had higher overall eating behavior scores. No other significant sex differences were observed in perceived stress, physical activity, mental toughness, or the individual eating behavior domains.

DISCUSSION

In this pilot study, participation in a structured multidisciplinary lifestyle intervention was associated with meaningful improvements in body composition in active-duty military personnel of both sexes. The most consistent changes were observed in body weight, body fat percentage, and BMI over the 6-month period. At the same time, the pattern of adaptation differed between men and women, indicating that the same intervention framework may yield sex-specific response patterns. These findings are consistent with the growing body of literature showing that lifestyle-related conditions, including overweight, obesity, and associated cardiometabolic risks, represent an increasingly important challenge in military populations, with direct implications for operational readiness, deployability, and long-term health outcomes [1–7].

From a physiological perspective, both sexes showed favorable reductions in adiposity-related indicators, while the magnitude and pattern of change differed. In men, the intervention period was accompanied by a significant increase in skeletal muscle mass in addition to reductions in body weight, BMI, and body fat percentage, while raw values also suggested a decrease in visceral fat. In women, significant reductions were observed in body weight, BMI, and body fat percentage, whereas the increase in skeletal muscle mass did not reach statistical significance. These findings are broadly in line with previous studies suggesting that sex-specific biological and metabolic factors may shape responses to diet- and exercise-related interventions [9–12,17,19,20]. Earlier reports have indicated that men often show more rapid improvements in lean mass and visceral adiposity, whereas women may differ in metabolic and behavioral adaptation patterns [9,10,12,19,20]. Such differences

Table 1. Sex-specific dietary, psychological, behavioral, physical activity and body composition characteristics at baseline (D0) and body composition parameters after a 6-month lifestyle intervention (D1) among active-duty Hungarian Defence Forces personnel, January 2024 – January 2025, Hungary

Variable	Participants (N = 40)		p
	men (N = 21)	women (N = 19)	
Energy intake [kcal/day] (M±SD)	2367.14±488.80	1800.53±389.72	<0.001
Perceived Stress Scale [pts] (M±SD)	11.76±6.11	15.00±8.77	0.189
Global Physical Activity Questionnaire [MET-min/week] (M±SD)	2322.86±2151.42	3630.95±6061.52	0.935
Transtheoretical model (M±SD)			
physical activity	22.52±11.26	24.58±12.36	0.587
nutrition	2.67±0.97	2.63±0.96	0.925
Uncontrolled eating (M±SD)	2.21±0.68	1.93±0.59	0.179
Cognitive restraint (M±SD)	2.28±0.45	2.37±0.47	0.569
Emotional eating (M±SD)	1.60±0.70	1.84±0.80	0.451
Overall eating behavior score (M±SD)	8.38±2.91	10.26±2.75	0.042
Mental Toughness Questionnaire [pts] (M±SD)	46.71±10.99	47.47±14.59	0.833
Body measurement (M±SD)			
D0			
body weight [kg]	108.49±22.63	84.49±13.44	<0.001
body fat [%]	29.10±7.29	43.23±5.52	<0.001
BMI [kg/m^2]	32.43±6.08	30.55±4.87	0.285
visceral fat [a.u.]	15.14±6.13	8.37±1.98	<0.001
muscle mass [kg]	33.03±4.08	24.69±2.05	<0.001
phase angle [°]	6.28±0.62	5.65±0.66	0.004
D1			
body weight [kg]	99.24±17.17	78.69±10.58	<0.001
body fat [%]	25.33±6.85	40.57±5.75	<0.001
BMI [kg/m^2]	29.70±4.60	28.28±3.76	0.290
visceral fat [a.u.]	12.55±4.65	7.74±1.82	<0.001
muscle mass [kg]	34.82±4.10	25.82±2.69	<0.001
phase angle [°]	6.15±0.58	5.44±0.61	<0.001

a.u. – arbitrary units.
BMI – body mass index.

may be related to hormonal influences, baseline body composition, and other sex-linked physiological factors.

Phase angle was also examined because it has been associated with hydration status, nutritional status, muscle quality, inflammation, and physical performance [13–15,21,22]. In the present study, phase angle values were higher in men than in women at both time points; however, the follow-up values do not support an interpretation of improvement over time. Therefore, phase angle findings should be interpreted cautiously in this sample. Nevertheless, the inclusion of phase angle may still be relevant in occupational and military health monitoring, given its reported associations with physical performance and overall physiological status in athletic and military contexts [14,15].

Psychological, behavioral, and physical activity variables were assessed only at baseline in the present study; therefore, no conclusions can be drawn regarding intervention-related changes in these domains. These measures should be interpreted as descriptive contextual characteristics rather than longitudinal outcomes. Baseline comparisons revealed broadly similar profiles be-

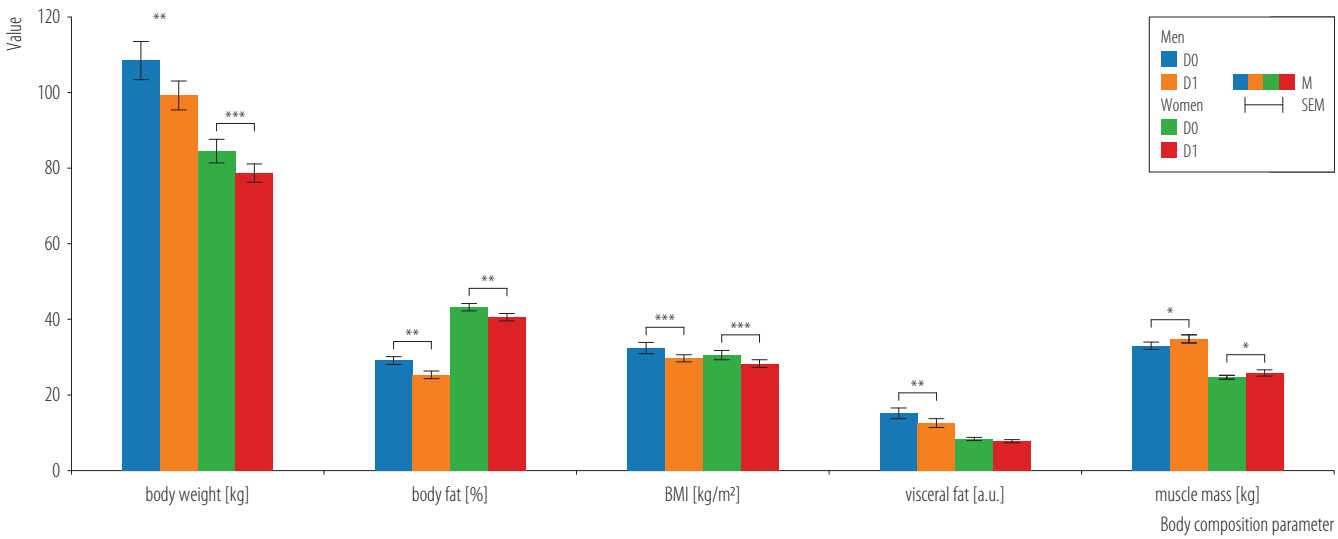
Table 2. Sex-specific body composition parameters at baseline (D0) and after a 6-month lifestyle intervention (D1) among active-duty Hungarian Defence Forces personnel, January 2024 – January 2025, Hungary

Variable	Participants (N = 40)				p
	men (N = 21)		women (N = 19)		
	D0	D1	D0	D1	
Body weight [kg] (M)	108.49	99.24	84.49	78.69	<0.001
BMI [kg/m²] (M)	32.43	29.70	30.55	28.28	0.290
Body fat [%] (M)	29.10	25.33	43.23	40.57	<0.001
Visceral fat [a.u.] (M)	15.14	12.55	8.37	7.74	<0.001
Muscle mass [kg] (M)	33.03	34.82	24.69	25.82	<0.001
Phase angle [°] (M)	6.28	6.15	5.65	5.44	<0.001

a.u. – arbitrary units.
BMI – body mass index.

tween men and women in perceived stress, physical activity, mental toughness, and most eating behavior domains, although women showed higher overall eating behavior scores and men reported higher daily energy intake. Motivational readiness was also comparable between sexes at baseline, suggesting broadly similar initial readiness profiles in both groups [26–28]. Accordingly, the present findings do not permit causal conclusions regarding the role of psychological or behavioral mechanisms in shaping the observed body composition changes. Because post-intervention dietary diary data were not analyzed in the present study, the contribution of negative energy balance to the observed body composition changes cannot be quantified directly.

From an occupational health perspective, the present findings have practical relevance. In the military environment, effective health promotion must support not only disease prevention but also performance, endurance, adaptability, and sustained readiness. Improvements in body composition may contribute to reduced injury risk, lower medical burden, and enhanced occupational functioning [1–7]. The present results suggest that structured multidisciplinary lifestyle programs may serve as useful components of military occupational



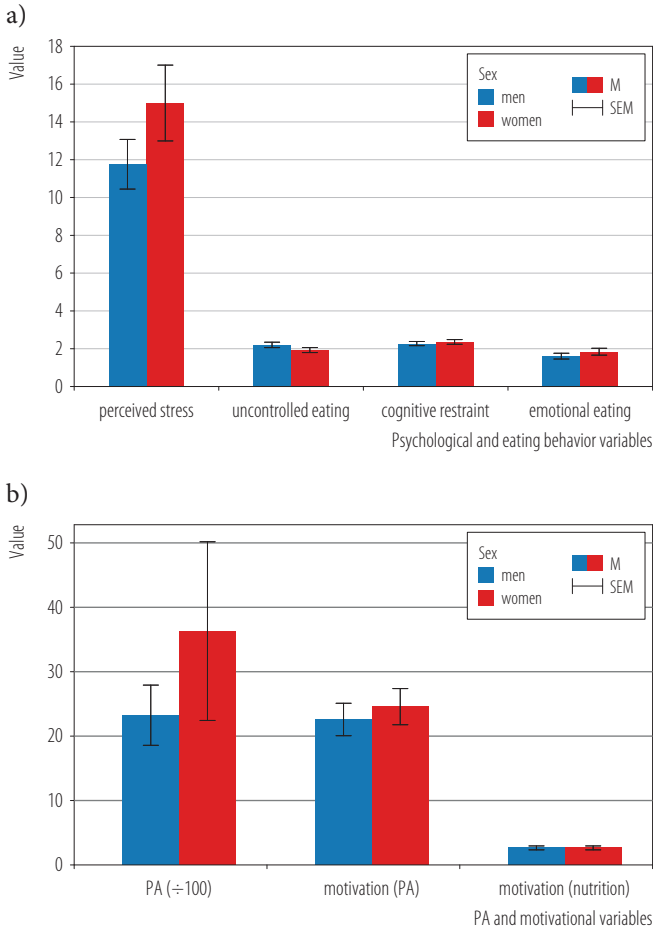
a.u. – arbitrary units, SEM – standard error of the mean.
BMI – body mass index.
Statistically significant within-group differences (D0 vs. D1) are indicated as follows: *p < 0.05, **p < 0.01, ***p < 0.001. Non-significant trends are not marked.

Figure 1. Body composition parameters at baseline (D0) and after a 6-month lifestyle intervention (D1) by sex among active-duty Hungarian Defence Forces personnel, January 2024 – January 2025, Hungary

Table 3. Within-group changes in body composition parameters from baseline (D0) to after a 6-month lifestyle intervention (D1) by sex among active-duty Hungarian Defence Forces personnel, January 2024 – January 2025, Hungary

Variable	Change (M±SD)	t (df)	p
Body weight [kg]			
men	−9.25±11.68	3.84 (20)	0.001
women	−5.79±5.88	3.20 (18)	0.005
BMI [kg/m²]			
men	−2.73±2.97	3.02 (20)	0.007
women	−2.27±2.47	2.45 (18)	0.024
Body fat percentage [%]			
men	−3.77±4.94	2.81 (20)	0.011
women	−2.66±3.53	2.35 (18)	0.030
Muscle mass [kg]			
men	+1.70±3.58	2.35 (20)	0.029
women	+1.13±1.76	1.98 (18)	0.063

BMI – body mass index.



SEM – standard error of the mean.
Physical activity (*Global Physical Activity Questionnaire*) values are scaled (÷100) for visualization purposes. Statistical differences between sexes were assessed using independent-samples t-tests.

Figure 2. a) Perceived stress and eating behavior variables, b) physical activity (PA) and motivational variables by sex among active-duty Hungarian Defence Forces personnel, January 2024 – January 2025, Hungary

health systems. At the same time, the sex-specific response patterns observed here indicate that a fully standardized approach may not maximize effectiveness. Tailored interventions that account for sex-specific physiological responses may improve both short-term outcomes and long-term sustainability [9–12,17–20].

The study also supports the view that intervention success should not be judged solely by gross anthropometric change. Although body weight and BMI remain useful clinical indicators, they may not fully reflect changes in muscle mass, fat distribution, or other physiologically relevant dimensions [6,9–12,13–15]. This is particularly important in occupational populations such as military personnel, where functional capacity is as important as body mass reduction. A multidimensional approach to outcome evaluation may therefore provide a more informative assessment of intervention response.

Several limitations should be acknowledged:

- first, the sample size was relatively small, particularly after stratification by sex, which limits statistical power and generalizability;
- second, the study used a non-randomized quasi-experimental design without a control group; therefore, the observed changes cannot be attributed exclusively to the intervention;
- third, some measures, including dietary intake and physical activity, relied partly on self-report and may therefore be affected by recall or reporting bias [30];
- fourth, detailed adherence to dietary recommendations and training participation, dietary supplement use, and comorbidities were not systematically recorded or quantified, which limits interpretation of intervention exposure;
- fifth, psychological, behavioral, and physical activity variables were assessed only at baseline, precluding evaluation of longitudinal change in these domains;
- finally, the difference between program participation and inclusion in the analytical dataset reflects the realworld constraints of military service, including service-related duties, illness, and incomplete documentation, and may have contributed to selection bias.

Future studies should evaluate larger cohorts and use controlled or randomized designs to confirm the

present findings. It would also be useful to examine the long-term sustainability of body composition changes and their relationship to occupational outcomes such as physical readiness, retention, and deployability. Repeated assessment of psychological and behavioral variables would further clarify whether these factors act as predictors, correlates, or mediators of intervention response.

CONCLUSIONS

Participation in a structured multidisciplinary lifestyle intervention was associated with meaningful improvements in body composition among active-duty military personnel and revealed distinct sex-specific response patterns. These findings support the integration of tailored, multidisciplinary lifestyle interventions into routine military health practice.

AI USE

Artificial intelligence-assisted tools were used for language editing and formatting support only. All scientific content and final approval remained the responsibility of the authors.

AUTHOR CONTRIBUTIONS

Research concept: Attila Novák, Tímea Téglás, Tibor Zoltán Lantos
Research methodology: Attila Novák, Tibor Zoltán Lantos
Collecting material: Attila Novák
Statistical analysis: Attila Novák
Interpretation of results: Attila Novák, Tímea Téglás, Tibor Zoltán Lantos
References: Attila Novák, Tímea Téglás

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