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THE IMPACT OF BODY WEIGHT ON POSTURAL MALALIGNMENT

Andreea MIHUȚĂ[1*], Adrian COJOCARIU[2]

ABSTRACT. This study aims to evaluate the impact of body weight on postural malalignment among a group of 82 participants, all employed by Ministry of Internal Affairs in Romania. Postural malalignment was assessed in the orthostatic position, in the sagittal plane, on the dominant (right) side. Joint angle values were determined using a goniometer, and the length of the thoracic spine was measured with a metric tape and the body weight with a electronic scale. Descriptive statistical analysis of the data, performed using SPSS software, indicated that the most significant weight ranges for the prevalence of malalignment were 86 kg (4.9%) and 90 kg (6.1%), suggesting a tendency for postural deviations in cases of higher body weight. Weights below 60 kg were very rare (1.2%), indicating a minor representation of individuals with low body weight within the subject group. Spearman correlation analysis revealed the existence of significant relationships between body weight and certain postural angles, suggesting that body mass is positively and significantly correlated (p=0.00) with the craniovertebral angle and the knee flexion angle. This supports the idea that individuals with higher weight exhibit evident postural adaptations in these segments, a phenomenon interpreted as a strategy to compensate for the displacement of the centre of gravity. Higher body weight was also associated with an elongation of the thoracic spine, perceived as an adaptive reaction to changes in body alignment and mass distribution, contributing to the support of body weight and postural stability. The absence of significant correlations between shoulder position and knee flexion, as well as between pelvic tilt and knee flexion, demonstrates that postural adaptation mechanisms can act selectively on certain muscle chains, without always involving the entire locomotor system. Furthermore, correlation analysis highlighted several significant relationships between postural parameters, revealing a complex model of biomechanical interdependence. The forward position of the head is directly

[1] Doctoral School in Sports and Physical Education Science, Faculty of Physical Education and Sports, "Alexandru Ioan Cuza" University of Iasi, 700554, Romania
[2] Faculty of Physical Education and Sports, "Alexandru Ioan Cuza" University of Iași, 700554, Romania
[*] Corresponding author: kinetoterapeutandreearosca@gmail.com

correlated with the forward position of the shoulders, confirming existing theories on ascending kinematic chains, according to which changes in head position induce adaptations at the level of the scapular girdle. Consequently, the research findings support the concept of postural interdependence between the upper and lower body segments. The significant correlations identified between alignment parameters demonstrate the existence of an integrated dysfunctional model, where adaptations in one segment generate compensatory changes in global postural alignment.

Keywords: body weight, postural malalignment, body postural angles, postural adaptation.

INTRODUCTION

Postural malalignments among police officers can lead to biomechanical imbalances, chronic musculoskeletal pain and reduced mobility, thereby affecting both health and operational performance. In the absence of specific data regarding employees of the Ministry of Internal Affairs (M.A.I) and the scarcity of studies relevant to the Romanian context, preliminary investigations are essential to determine the magnitude and severity of the problem, thereby facilitating the prevention of related risks, injuries, functional impairments, and occupational incapacity.

Studies of Yip et al. (2008) and Quek et al. (2013) have highlighted a functional relationship between the anteriorization of the head and the position of the shoulder girdle, supporting the idea of an interdependent postural chain between the head, neck and shoulders. Sustained efforts of the cervical muscles can lead to localized fatigue and accentuation of the curvature of the spine in this segment, thus affecting cervical alignment by altering the cranio-vertebral angle (Waersted et al., 2010; Zhou et al., 2024).

Malalignment of the knee and pelvis generates a functional imbalance, which overloads the lumbosacral region, thus supporting the link between poor segmental alignment (Hofste et al., 2021; Simonet et al., 2020). Ohko and Ota (2023) point out that biomechanical changes, especially those related to knee flexion can negatively influence the postural alignment of the lower limb, thus strengthening the hypothesis of postural adaptation. The study by Downie et al., (2025) supports the idea that accentuated knee flexion is a compensatory strategy for maintaining balance, especially in the context of biomechanical limitations.

Kett et al., (2021) highlighted the fact that changes in postural alignment, especially in the lumbar and thoracic area, can cause an increase in muscle stiffness and loads on the spine, depending on the supported positions and

morphological characteristics of the individual. Thus, the length of the body segments and the positioning of the center of gravity can lead to compensatory adjustments of the position of the head and knees, visible at the larger angles observed.

Overall, these results reflect the complexity of the interactions between body morphology and postural adaptations.

The purpose of this research was to analyze the prevalence of postural malalignment among the Romanian police workers, identifying the associated risk factors like the body weight, in order to validate proposals for preventive and corrective measures aimed at improving physical functionality and professional efficiency.

The objective was to detect how the body weight influence the prevalence of postural malalignment, by analyzing and interpreting the collected data, in order to identify and understand the variables associated with the occurrence of this postural deviation.

MATERIAL AND METHODS

Participants

The subjects of the research are represented by police officers from the representative structures for the activity of the Romanian Border Police, employees of the Ministry of Internal Affairs, who met the selection criteria to be included in the study. The participants are part of various operational work units such as: service shifts, surveillance and control, operational support, combating cross-border crime, control-access, which carry out activities in the field for the surveillance and control of the state border, in fixed points for guarding objectives, patrols, control of persons, cars and documents, in traffic or participate in interventions, but also with non-operative specificity: administrative offices, logistics, secretarial, procurement, finance, communications and training departments within the Initial and Continuous Training School of the Border Police, representing a wide spectrum of roles within the Border Police. Subjects of both genders and different age groups reflect the actual composition of M.A.I. employees, which reduced the possibility of selection bias. This ensures that the study group is not limited to just certain types of employees and is representative of the entire institution.

Participants were informed about the objectives of the study and the purpose of the research, the procedures involved, including data collection methods, biomechanical measurements and the right to be able to withdraw at any time without negative consequences. Subjects gave their consent to participate

freely, informedly, and voluntarily in the research by signing a standardized consent form that included the statement of consent, confirmation that they understood the purpose and methods of the study, consent to the anonymous use of the data collected, and details about the preservation of confidentiality.

Considering that the participants are employees of the Ministry of Internal Affairs, the official approval was requested from the director of the Initial and Continuous Training School of the Border Police of Iasi and the Head of the Territorial Inspectorate of the Border Police of Iaşi, for which inter-institutional collaboration contracts were made and compliance with the internal regulations on investigations involving the personnel of the Ministry of Internal Affairs was ensured.

At the beginning of the study, we considered a number of 237 police workers, but following the application of the selection criteria, the number of subjects was reduced to 150 participants. *Inclusion criteria:* active employees within the Ministry of Internal Affairs; availability for voluntary participation; age between 20 - 55 years; each participant held the approval of the unit doctor, confirming their medical fitness for engaging in physical effort. *Exclusion criteria:* history of severe neurological disorders or structural deformities of the musculoskeletal system, of recent spine or joint surgery; lack of consent to participate, including refusal or omission to sign the informed consent document.

Based on the assessment of postural malalignments conducted through standardized measurement protocols, 82 of the 150 participants exhibited deviations from the optimal body angle values.

Procedure

The measurement procedures were performed during the period February–April 2025, in the gym of the Initial and Continuous Training School of the Iasi Border Police, under the same conditions for all participants. The subjects were instructed to maintain an orthostatic position characterized by a natural and comfortable posture throughout the evaluation process. A laser pointer helped maintain eye level through a dot marked directly in front of each participant. We determined the cranio-vertebral angle (icva), the forward shoulder angle (ifsa), the pelvic tilt angle (ipt) and the knee flexion angle (ikf), in the sagittal plane, on the dominant side (right) and measured it in degrees. Estimation of thoracic kyphosis was summarized to measuring the curvature of the thoracic spine in centimeters, and weight was measured in kilograms.

Ideal postural alignment angles values are: cranio-vertebral (icva) = 55°, shoulder alignment (ifsa) = 0°, pelvic angle (ipt) = 0–15°, and knee flexion (ikf) = 0–10°, ensuring proper spinal alignment and weight distribution (Magee & Manske, 2021).

Materials

The evaluation of anatomical body angles was performed with the goniometer, utilized as a precise instrument for quantifying postural malalignments, that reproduces the degrees of inclination between two body segments. The assessment of thoracic kyphosis was conducted using a metric measuring tape, whereas body weight was determined with a calibrated electronic scale.

Data analysis

For the analyses we used SPSS software, version 20 ($\alpha = 0.05$). The Shapiro – Wilk Test was used to assess the normality of the data distribution in our group of subjects. The Sig. value p= 0.009, lower than 0.05, suggests rejecting the hypothesis of normality.

RESULTS

Based on the statistical analysis and the graphical representations in Figure 1 (histogram and boxplot of the body weight variable generated in SPSS), the body weight of police officers exhibiting postural malalignments was found to range from 56 kg to 108 kg, reflecting a relatively wide dispersion of values across the sample. The most frequently body weight reported among the subjects associated with postural malalignment was recorded at 90 kg, followed by 86 kg, both values with percentages of 6.1% and 4.9%, respectively. Other commonly encountered body weight ranges are 64 kg, 74 kg and 94 kg, each with a percentage of 3.7%. The most common weight ranges: 90 kg (6.1%) and 86 kg (4.9%) are the most represented, suggesting a higher prevalence of malalignment in police officers with higher body weights. Weights under 60 kg are very rare, with only 1.2% of police officers weighing 56 kg, indicating a minor representation of those with low weight within the group of subjects. The majority (67.1%) have a body weight of less than 90 kg, while only 32.9% are equal to or above 90 kg.

This distribution suggests that, within this group affected by malalignment, subjects with higher body weight are not predominantly represented. The Chi-square test was used to examine whether the proportions of subjects with malalignment differ significantly based on body weight categorized below and above 90 kg. The results show a statistically significant difference between the two groups, $\chi^2(1) = 9.561$, $p = 0.002$, the number of those weighing less than 90 kg is significantly higher.

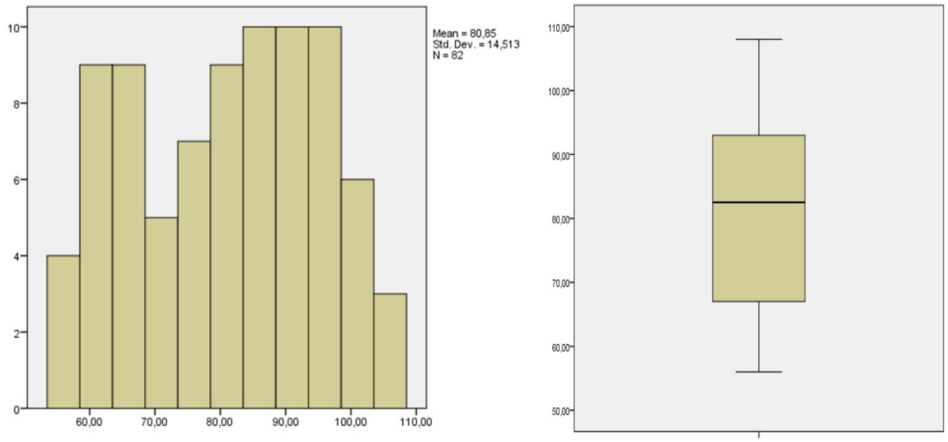
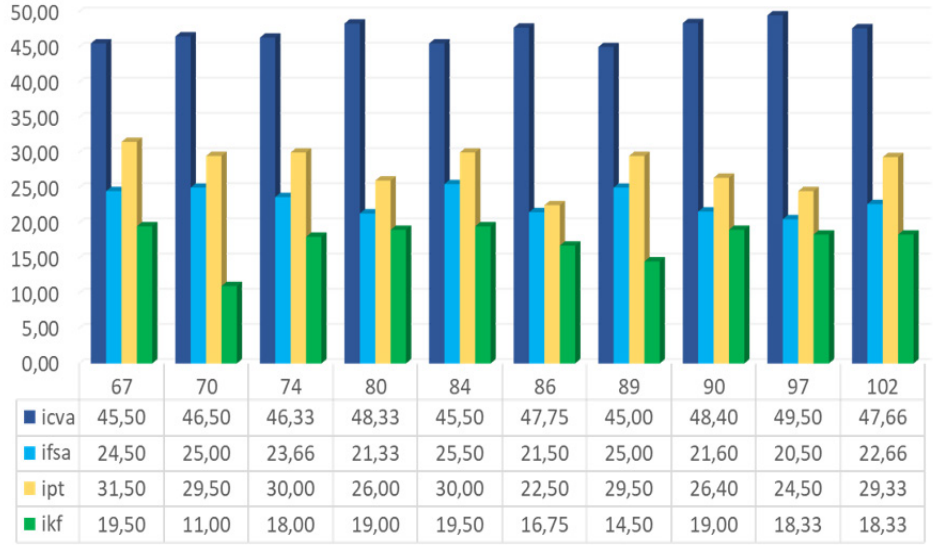


Fig. 1. Histogram and boxplot of the variable body weight according to SPSS

Fig.2 illustrates the comparative graph for the distribution of the average values of the body angles of the subjects with misalignments, according to weight. Spearman's analysis of correlations reveals significant relationships between body weight and certain postural angles, suggesting that body mass may influence the alignment of body segments.



	67	70	74	80	84	86	89	90	97	102
icva	45,50	46,50	46,33	48,33	45,50	47,75	45,00	48,40	49,50	47,66
ifsa	24,50	25,00	23,66	21,33	25,50	21,50	25,00	21,60	20,50	22,66
ipt	31,50	29,50	30,00	26,00	30,00	22,50	29,50	26,40	24,50	29,33
ikf	19,50	11,00	18,00	19,00	19,50	16,75	14,50	19,00	18,33	18,33

Fig. 2. Distribution of body angle values according to body w eight

The results, according to Table no.1, highlight a moderate positive correlation between body weight and cranio-vertebral angle (icva), with a coefficient of 0.536 and a significance level of p = 0.000. A higher body weight may be associated with increased muscle mass among our subjects, which could explain the lower prevalence of postural malalignments observed in police officers weighing more than 90 kg. These findings indicate that police officers with lower body weight are more likely to present a forward head posture, which may represent a biomechanical adaptation associated with inadequate muscle development.

According to Table no.1, a moderate and significant positive correlation between body weight and knee flexion angle (ikf) is also observed, with a coefficient of 0.547 and p = 0.000, suggesting that heavier police officers may exhibit accentuated knee flexion in a static position, presumably to maintain stability and balance.

Table 1. Spearman's correlations between the independent variable body weight and dependent variables: body angles and spine length.

Variable	Weight	Icva	Ifsa	Ipt	Ikf	Iky
Weight	1.000	0.536**	-0.164	-0.138	0.547**	0.799**
p	-	0.000	0.141	0.215	0.000	0.000
Icva	0.536**	1.000	-0.404**	-0.251*	0.339**	0.256*
p	0.000	-	0.000	0.023	0.002	0.020
Ifsa	-0.164	-0.404**	1.000	0.289**	0.067	0.076
p	0.141	0.000	-	0.008	0.550	0.499
Ipt	-0.138	-0.251*	0.289**	1.000	0.113	-0.175
p	0.215	0.023	0.008	-	0.313	0.116
Ikf	0.547**	0.339**	0.067	0.113	1.000	0.524**
p	0.000	0.002	0.550	0.313	-	0.000
Iky	0.799**	0.256*	0.076	-0.175	0.524**	1.000
p	0.000	0.020	0.499	0.116	0.000	-

**Correlations are significant at the level of 0.05 (2-tailed).*
***Correlations are significant at the level of 0.01 (2-tailed).*

The forward shoulder angle (ifsa) and the pelvic tilt angle (ipt) do not have significant relationships with body weight, having coefficients of -0.164 (p = 0.141) and -0.138 (p = 0.215), according to Table no.1, which suggests that these postural components are not directly influenced by body weight, but rather by other functional factors or specific to professional activity.

Fig.3 shows the comparative graph for the distribution of the mean values of the length of the thoracic spine, of the subjects with malalignments, according to the weight variable.

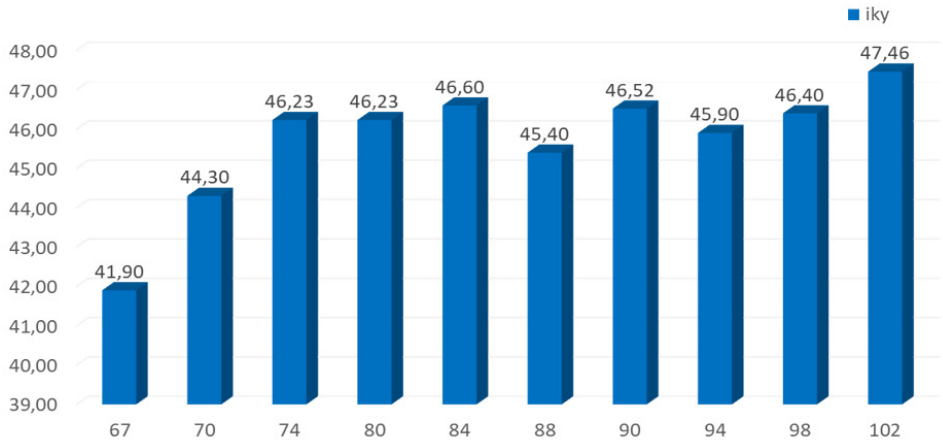


Fig. 3. The length of the thoracic spine according to body weight.

Analysis of the Spearman correlation between body weight and thoracic spine length (iky), suggests a significant association. With a correlation coefficient of 0.799 and a significance value of p = 0.000, according to Table no.1, the results indicate a strong positive correlation between body weight and thoracic spine dimensions. This suggests that police officers with higher body weight tend to have a longer thoracic spine length, which may be interpreted as an adaptive mechanism aimed at compensating for weight distribution and maintaining postural stability.

The analysis of correlations highlighted several significant relationships between postural parameters, revealing a complex pattern of biomechanical interdependencies. In the case of the correlation between craniovertebral angle (icva) and forward shoulder position (ifsa), a strong negative association was observed with a coefficient of -0.404 ($p<0.01$), indicating that head anteriorization correlates directly with shoulder anteriorization. This finding confirms existing theories on ascending kinematic chains, according to which changes in the position of the head induce adaptations at the level of the shoulder gridle.

We identified a moderate positive correlation between craniovertebral angle and knee flexion with a coefficient of 0.339 ($p<0.01$), suggesting the existence of a compensatory mechanism by which subjects with anterior cranial position develop an accentuated knee flexion to maintain postural balance. This phenomenon can be interpreted as a strategy to compensate for the displacement of the center of gravity.

At the moderate significance threshold ($p<0.05$), the analysis revealed a negative correlation between craniovertebral angle and pelvic tilt with a coefficient of 0.251, as well as a positive relationship between forward shoulder position

and pelvic tilt with a coefficient value of 0.289. These results support the concept of postural interdependence between upper and lower body segments, demonstrating how postural adaptations at one level can influence body alignment at other levels.

The analysis did not identify significant relationships ($p > 0.550$) between shoulder position and knee flexion, respectively between pelvic inclination and knee flexion. These results may suggest that postural adaptation mechanisms may act selectively on certain muscle chains, without always involving the entire musculoskeletal system.

DISCUSSION

The findings strengthen the concept of postural interdependence between upper and lower body segments, indicating that compensatory adaptations within one region can influence the alignment and functional stability of other segments.

The significant correlations identified between body angles (craniovertebral, forward shoulder angle, knee flexion and pelvic tilt) support the existence of an integrated dysfunctional model, wherein adaptations of a segment may influence the overall postural alignment. This result corroborates existing theories regarding ascending kinematic chains, suggesting that alteration in head posture can trigger compensatory adjustments within the shoulder girdle. Moreover, these results indicate that postural adaptation mechanisms may act selectively on certain muscle chains, rather than involving the entire musculoskeletal system simultaneously.

The results indicate the existence of a compensatory mechanism through which individuals displaying an anterior cranial posture develop accentuated knee flexion as a means of preserving postural stability. This adaptation may be understood as a corrective strategy to offset the forward shift of the body's center of gravity.

The study suggests that higher body weight may reflect greater muscle mass and that, in the context of postural malalignment assessment, well-developed musculature could serve a protective function by promoting optimal biomechanical alignment and thereby reducing the risk of postural deviations.

According to the study by Ku et al. (2012), body weight exerts a notable effect on static postural control. People with higher body weight, especially those in the obesity category, have poorer postural control, which can cause biomechanical adjustments, such as a more pronounced bend of the knees, to maintain stability and balance in a static position. The research of Delgado et al., (2021) and Liew et al., (2020) support our results in the case of excess weight that influences the center of gravity and global posture, and this effect is amplified in conditions of physical effort, vicious positions and lack of neuromuscular recovery. Consequently, the

study posits that postural adaptations, including increased knee flexion, may represent compensatory mechanisms aimed at mitigating the biomechanical challenges associated with body weight and preserving postural equilibrium.

CONCLUSIONS

The results indicate that increased body weight may be associated with enhanced muscle mass, potentially explaining the reduced occurrence of postural malalignments among police officers exceeding 90 kg. Conversely, those with lower body weight tend to display a forward head posture, which may reflect a compensatory biomechanical adaptation linked to suboptimal muscle development.

Body weight correlates significantly with craniovertebral and knee flexion angles, which involves obvious postural adaptations in these segments. However, the lack of significant correlations with shoulder and pelvic angles suggests that the influence of weight on posture is not uniform and may vary depending on other individual factors.

The association between higher body weight and thoracic spine elongation suggests an adaptive biomechanical mechanism through which the body compensates for changes in postural alignment and load distribution, thereby supporting overall stability and weight-bearing efficiency.

Body weight may be a determinant of the postural alignment and the results of the present study indicate an inverse association between body weight and the prevalence of postural malalignments among subjects, suggesting that higher weight associated with increased muscle mass, may contribute to enhanced postural stability and reduced malalignment risk.

AUTHOR CONTRIBUTIONS

Andreea Mihuță and Adrian Cojocariu played key roles in the design and implementation of the research, the analysis of the results, and the preparation of the manuscript. Both authors have reviewed and approved the final version of the manuscript for publication.

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