

Chair posture detection with force platform

Epishev Vitaliy Viktorovich
Director of the Research Center for Sports Science, Associate Professor, Department of Theory and Methods of Physical Education and Sports, Institute of Sport, Tourism and Service
South Ural State University
Chelyabinsk, Russia
epishev74@mail.ru
0000-0002-7284-7388

Yakhin Dmitry Khadinurovich
Postgraduate Student, Department of Theory and Methods of Physical Education and Sports, Institute of Sport, Tourism and Service
South Ural State University
Chelyabinsk, Russia
yahin1@rambler.ru
0000-0001-6595-4735

Gapicheva Maria Andreevna
Postgraduate Student, Department of Theory and Methods of Physical Education and Sports, Institute of Sport, Tourism and Service
South Ural State University
Chelyabinsk, Russia
kokosananaskokos@mail.ru
0000-0002-0276-6291

Abstract

The purpose of the article is to determine the possibility of diagnosing various sitting positions according to the dynamics of W_{MEAN} . Materials and methods: 19 people (10 males and 9 females) aged from 16 to 50 years were examined. The Force platform MBN "Stabilo" was installed on a chair and 8 tests were carried out with various poses followed by the analysis of the dynamics of W_{MEAN} (kg). Results: Spearman correlation results show high r values (from 0.87 to 0.96, $p \leq 0.05$). According to the 2D Scatterplot, an almost linear dependence was revealed, regression equations were obtained for each pose. Conclusion: the possibility of creating an equipment for tracking the time of the "right/wrong" position using the W_{MEAN} tracking algorithm is shown.

Keywords. chair posture detection, force platform, posture, weight measurement.

I INTRODUCTION

The problem of a sedentary lifestyle and its consequences remains relevant everywhere. Starting from school, a modern person gets used to working in a sitting position, which leads to inactivity and impaired functioning of various body systems [2]. Prolonged sitting adversely affects the spine, as muscle and ligament tension arising in the body is compensated by a change in sitting position. This leads to fixation of stresses, consolidation of anatomical shifts and even greater postural disturbance. Assessment of the pressure and control for various postures in a sitting position were considered in a number of studies. In some studies, an analysis of the pressure force and its distribution in a sitting position was previously performed [5, 9, 14]. R.H. Goossens et al. examined pressure around the left buttock and on the is chialtuberclle [6, 7], M.P. DeLooze et al. - uniform distribution of pressure in the seat pan and chair back [4], S.M. Carconeand P.J. Keir studied the area of contact with the seat and the average pressure in the seat [3], and also in some studies the maximum pressure in the seat was studied [3, 8, 10].

Conclusions are drawn that this issue is subject to further development and detailed study, as the relationship of prolonged sitting with an increased risk



of developing diseases of the musculoskeletal system has not been studied enough [11, 13, 15]. At the same time, it was found that to evaluate various postures in a sitting position, the most effective is the use of instruments and systems that measure weight and its distribution [12].







II. MATERIALS AND METHODS

The study was carried out on the premises of the Research Center for Sports Science of the South Ural State University (National Research University). The study was conducted with the help of the stabilometric platform MBN "Stabilo", with a pre-marked sitting area of 380 * 360 mm. The platform was mounted on a chair in a stable position. Under the legs, to compensate for the height of the platform (6 mm), a stand of a similar height was installed. A total of 19 people were examined (10 males, 9 females) aged 20 to 50 years. We analyzed 1 parameter corresponding to the coordinate of the body position Z - W_{MEAN} (kg) - mean weight.

Eight tests were carried out in various sitting positions (Table 1).

TABLE I – SITTING POSITIONS

	Sitting straight (1)
	Sitting legs under a chair (2)

	Sitting elbows on knees (3)
	Sitting elbows on knees with mobile phone (4)
	Sitting left leg on the right (5)
	Sitting right leg on the left (6)
	Sitting back relaxed (7)
	Sitting with hands on a table (8)

Statistical analysis of the results was carried out using the STATISTICA 10.0 program. The calculation of Mean, Standard Deviation, Spearman, 2D Scatterplot (graph type - Regular, fit type - linear), as well as linear regression analysis was performed.

III. RESULTS AND DISCUSSION

Table 2 shows the dynamics of W_{MEAN} at various sitting positions. The table shows that W_{MEAN} changes with various poses. So, its minimum values are fixed

when sitting elbows on knees, and the maximum when sitting legs under a chair. Figure 1 shows the relative dynamics of W_{MEAN} (W_{MEAN} when sitting straight is taken as 100%).

Table 2. Dynamics of W_{MEAN} (kg) with various sitting positions

	Mean	Std. Dev
Sitting straight (1)	34.75	14.41
Sitting legs under a chair (2)	40.70	16.34
Sitting elbows on knees (3)	20.20	12.19
Sitting elbows on knees with mobile phone (4)	21.35	13.06
Sitting left leg on the right (5)	34.19	13.64
Sitting right leg on the left (6)	33.87	14.33
Sitting back relaxed (7)	27.41	13.27
Sitting with hands on a table (8)	22.55	10.74

The smallest W_{MEAN} values were observed in the sitting elbows on knees (3) position, the highest in sitting legs under a chair (2). Figure 1 shows the relative dynamics of W_{MEAN} (W_{MEAN} when sitting straight is taken as 100%).

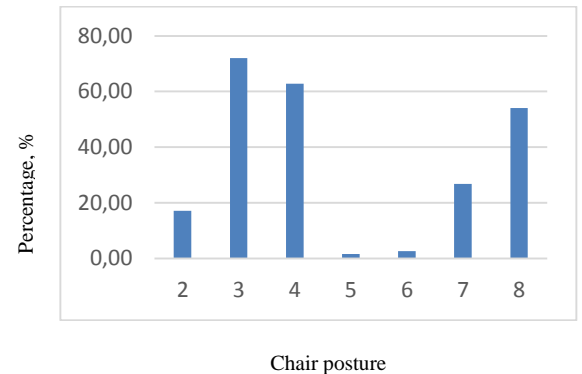


Fig. 1 The relative dynamics of W_{MEAN} with various sitting positions

It can be supposed that according to the variability of W_{MEAN} , some positions of a person in a chair can be predicted. In particular, in the range of 20% change are sitting legs under a chair (2), sitting left leg on the left (5) and sitting right leg on the left (6). In the range of 20-30% is sitting back relaxed (7), in the range of 40-50% - sitting with hands on a table (8), in the range of 60-80% - sitting elbows on knees (3) and sitting elbows on knees with mobile phone (4). The most difficult for chair posture detection are the poses sitting left leg on the right and setting right leg on the left, because their W_{MEAN} values are very close to sitting straight. Therefore, to determine these poses, it is necessary to measure additional parameters, for example, mean location of center of pressure in the frontal plane and mean location of center of pressure in the sagittal plane.

Due to the fact that the study involved male and female volunteers with different body weights (W_{min}

- 52.3 kg, Wmax - 107.2 kg) Std values. Dev and therefore the coefficient of variation were extremely high. It was decided to calculate the correlation coefficient of each of the seven positions (Table 3). Table 3 shows that the results obtained indicate a high relationship between postures in the chair, not depending on the gender of the person and his weight.

Table 3 Correlation between W_{MEAN} (kg) at different sitting positions (in all cases (p≤0.05))

	1	2	3	4	5	6	7
1							
2	0.96						
3	0.92	0.87					
4	0.88	0.89	0.94				
5	0.99	0.94	0.92	0.88			
6	0.98	0.97	0.91	0.87	0.98		
7	0.92	0.92	0.86	0.83	0.94	0.92	
8	0.96	0.94	0.96	0.91	0.95	0.96	0.92

To analyze the W_{MEAN} dependence when Sitting straight and in other poses, we performed a graphical construction of a 2D Scatterplot (Figures 2-8) with the calculation of the linear regression equation. Figure 2 shows the relationship between W_{MEAN} in the Sitting straight and Sitting legs under a chair positions.

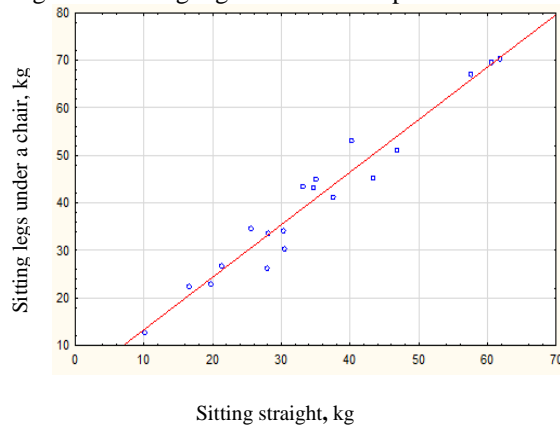


Fig. 2. W_{MEAN} relationship between the Sitting straight and Sitting legs under a chair positions

The use of regression analysis made it possible to obtain a regression equation, based on which the Sitting legs under a chair position can be predicted according to the change in W_{MEAN}.

Sitting legs under a chair (kg) = 2.2696 + 1.106 * Sitting straight (kg)

Figure 3 shows the relationship between W_{MEAN} in Sitting straight and Sitting elbows on knees.

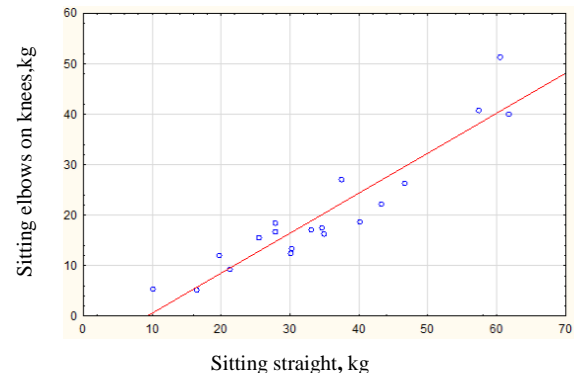


Fig. 3. W_{MEAN} relationship between the Sitting straight and Sitting elbows on knees positions

The linear regression equation has the form:

Sitting elbows on knees (kg) = -7.327 + 0.7923 * Sitting straight (kg)

Figure 4 shows the relationship between W_{MEAN} in Sitting straight and Sitting elbows on knees with mobile phone.

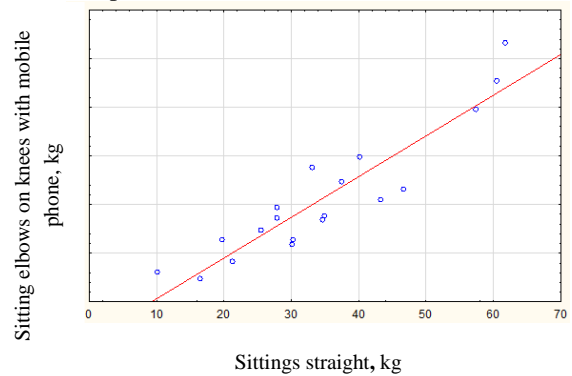


Fig. 4. W_{MEAN} relationship between the Sitting straight and Sitting elbows on knees with mobile phone positions

The linear regression equation has the form:

Sitting elbows on knees with mobile phone (kg) = -7.7161 + 0.8366 * Sitting straight (kg)

Figure 5 shows the relationship between W_{MEAN} in Sitting straight and Sitting left leg on the right.

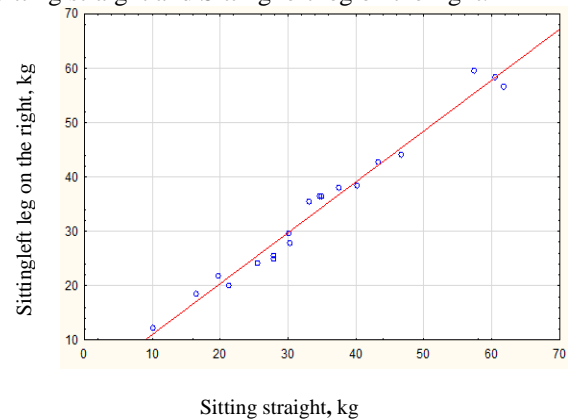


Fig. 5. W_{MEAN} relationship between the Sitting straight and Sitting left leg on the right positions

The linear regression equation has the form:

Sitting left leg on the right (kg) = 1.6774 + 0.9357 * Sitting straight (kg)

Figure 6 shows the relationship between W_{MEAN} in Sitting straight and Sitting right leg on the left.

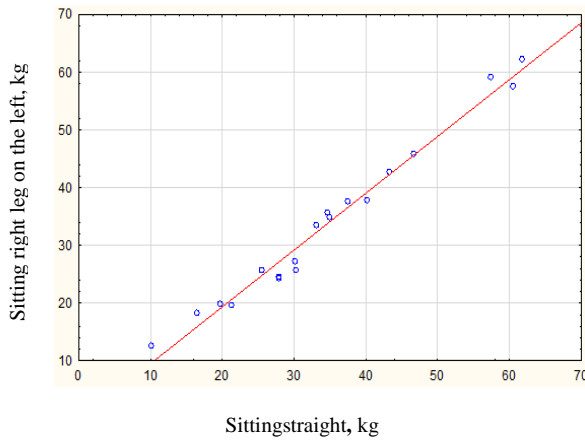


Fig. 6. W_{MEAN} relationship between the Sitting straight and Sitting right leg on the left positions

The linear regression equation has the form:

Sitting right leg on the left (kg) = -0.3296 + 0.9843 * Sitting straight (kg)

Figure 7 shows the relationship between W_{MEAN} in Sitting straight and Sitting back relaxed.

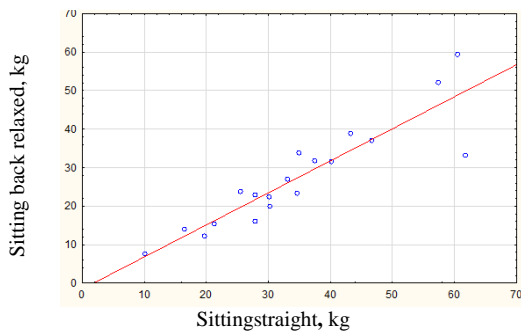


Fig. 7. W_{MEAN} relationship between the Sitting straight and Sitting back relaxed positions

The linear regression equation has the form:

Sitting back relaxed (kg) = -1.5064 + 0.8321 * Sitting straight (kg)

Figure 8 shows the relationship between W_{MEAN} in Sitting straight and Sitting with hands on a table.

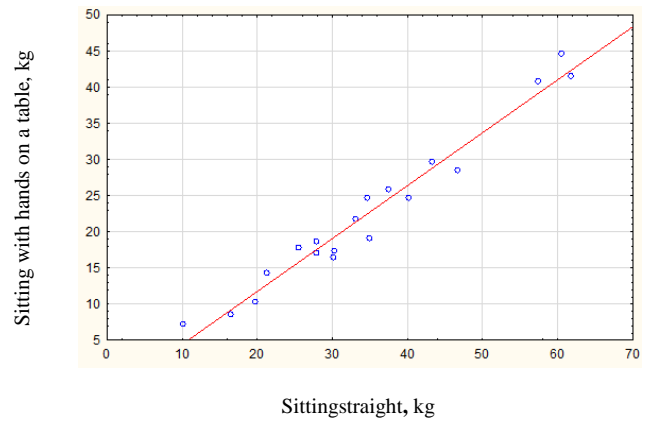


Fig. 8. W_{MEAN} relationship between the Sitting straight and Sitting with hands on a table positions

The linear regression equation has the form:
Sitting with hands on a table (kg) = -2.8912 + 0.7321 * Sitting straight (kg)

IV. CONCLUSION

The results of the study show that W_{MEAN} changes at different sitting positions. Spearman correlation results demonstrate high r values (from 0.87 to 0.96, $p < 0.05$) and, according to 2D Scatterplot, an almost linear relationship. For each position, regression equations were obtained, the use of which can make it possible to create an equipment for tracking the time of the “right / wrong” position. Further research in this direction, in particular with schoolchildren, will make it possible to create a posture control device with feedback, which, will reduce the number of spine diseases.

REFERENCES

- [1] Checalova, N.G., Kusmichev, U.G., Checalova S.A., Kozinec A.A. The monitoring of deviations of osteomuscular system of children from the different educational stages at school. Vestnik uralskoi meditsinskoi akademicheskoi nauki. 2010. Vol. 1 (28), pp. 13-16.
- [2] Serganova T.I. How to defeat cerebral palsy. St. Petersburg, 1995 . 205 p.
- [3] Carcone, S.M., Keir P.J. Effects of backrest design on biomechanics and comfort during seated work. Ergonomics. 2007, 38, pp. 755-764
- [4] M.P. De Looze, L.F. Kuijt-Evers, J. Dieen Sitting comfort and discomfort and the relationships with objective measures. Ergonomics. 2003, vol. 46, pp. 985-997
- [5] N.M. Dunk, J.P. Callaghan Gender-based differences in postural responses to seated exposures. Clin. Biomech. 2005, vol. 20, pp. 1101-1110
- [6] Goossens R. H. Measuring factors of discomfort in office chairs. Ergonomics, Elsevier, 1998; pp. 371-374
- [7] Goossens, R. H. Sensitivity for pressure difference on the ischial tuberosity. Ergonomics. 2005, 48, pp. 895-902
- [8] Groenesteijn, L. Effects of differences in office chair controls, seat and backrest angle design in relation to tasks. Ergonomics. 2009, vol. 40, pp. 362-370
- [9] Mota, S., Picard, R.W.: Automated Posture Analysis for Detecting Learner’s Interest Level. In: Computer Vision and Pattern Recognition Workshop. 2003
- [10] Noro, K A theory on pressure distribution and seat discomfort. Vink Comfort and Design. CRC Press. 2005, pp. 33-39.
- [11] Naqvi, S.A. Study of forward sloping seats for VDT workstations. Ergol. 1994, 23, pp. 41-49.
- [12] Roland, Z. Are pressure measurements effective in the assessment of office chair comfort/discomfort? A review. Ergonomics. 2015, vol. 48, pp. 273-282

- [13] Roland, Z. Occupational sitting behaviour and its relationship with back pain – A pilot study. *Appl. Ergon.* 2016, vol. 56, pp. 84-91
- [14] What does your chair know about your stress level? *Ieee T Inf. Technol. B.* 2010, 1vol. 4, pp. 207-214
- [15] Winkel, J. and Jorgensen, K. Evaluation of foot swelling and lower-limb temperatures in relation to leg activity during long-term seated office work. *Ergonomics.* 1986, vol. 29, pp. 313-328..