BG Pulse Journal USA
ISSN:1947-2536 http://www.bgpulseusa.com/index.php/bg

STUDY OF THE ERGONOMIC CHARACTERISTICS OF SPECIAL-PURPOSE CLOTHING

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doi:https://doi.org/10.5281/zenodo.23794473

Abstract. Special-purpose garments require ergonomic verification because restricted mobility, unstable fit, localized pressure, and thermal discomfort can reduce task performance and wearer acceptance. This study evaluated a prototype through an ergonomic evaluation study involving 30 participants. Anthropometric measurements included height and body mass, while comfort was assessed through a structured point scale covering mobility, fit, pressure distribution, and thermal sensation. Taguchi signal-to-noise analysis and ANOVA were applied to compare comfort responses, and measurement uncertainty was estimated with a reproducible calculation formula. Twenty-two participants, representing 73.3 % of the sample, rated the clothing comfortable; six participants, or 20.0 %, reported moderate comfort, and two participants, or 6.7 %, found it uncomfortable. The mean garment comfort score was 4.1 points. Compared with the less favorable moderate and uncomfortable responses, the dominant comfortable rating indicates acceptable ergonomic performance, although pressure redistribution and seam placement remain important design variables. The contribution of the study is an integrated assessment scheme linking mobility, fit, pressure distribution, and thermal comfort within one garment-evaluation procedure.
Keywords: garment fit, mobility restriction, pressure distribution, protective apparel, thermal comfort, wearability assessment

Annotatsiya. Maxsus maqsadli kiyimlar harakatni cheklashi, gavdaga beqaror moslashishi, ayrim joylarda bosim hosil qilishi va issiqlik noqulayligini kuchaytirishi sababli ergonomik tekshiruvni talab etadi. Mazkur ishda 30 nafar ishtirokchi qatnashgan ergonomik baholash tadqiqoti orqali tajriba namunasi sinovdan o‘tkazildi. Antropometrik o‘lchovlarda bo‘y va tana massasi qayd etildi, qulaylik esa harakatchanlik, moslik, bosim taqsimoti va issiqlik sezgisini qamrab olgan ballik shkala yordamida baholandi. Qulaylik javoblarini taqqoslash uchun Taguchi signal-shovqin tahlili va dispersiya tahlili qo‘llanib, o‘lchash noaniqligi takrorlanadigan hisoblash formulasi bilan aniqlandi. Yigirma ikki ishtirokchi, ya’ni tanlovning 73,3 foizi, kiyimni qulay deb baholadi; olti kishi, 20,0 foiz, o‘rtacha qulaylikni, ikki kishi, 6,7 foiz, esa noqulaylikni ko‘rsatdi. Kiyimning o‘rtacha qulaylik bali 4,1 ballni tashkil etdi. Qulay baholarning ustunligi maqbul ergonomik ko‘rsatkichni bildiradi, biroq bosimni qayta taqsimlash va chok joylashuvi muhim konstruktiv omil bo‘lib qoladi. Ishning hissasi to‘rtta ergonomik mezonni yagona baholash tartibida birlashtirishdan iborat.
Kalit so‘zlar: gavdaga moslik, harakat cheklanishi, bosim taqsimoti, himoya kiyimi, issiqlik qulayligi, kiyinish qulayligini baholash

Аннотация. Одежда специального назначения нуждается в эргономической проверке, поскольку ограничение движений, нестабильная посадка, локальное давление и тепловой

дискомфорт способны снизить рабочую эффективность и приемлемость изделия. В работе опытный образец оценивали в рамках эргономического исследования с участием 30 человек. Антропометрическая часть включала измерение роста и массы тела, а комфорт определяли по балльной шкале, охватывавшей подвижность, посадку, распределение давления и тепловые ощущения. Для сопоставления оценок применяли анализ отношения сигнал/шум Тагути и дисперсионный анализ; неопределенность измерений рассчитывали по воспроизводимой формуле. Двадцать два участника, или 73,3 % выборки, признали одежду комфортной; шесть человек, 20,0 %, отметили умеренный комфорт, а два человека, 6,7 %, сочли ее неудобной. Средняя оценка комфорта изделия составила 4,1 балла. Преобладание положительных оценок указывает на приемлемую эргономичность по сравнению с умеренными и отрицательными ответами, однако перераспределение давления и расположение швов остаются значимыми конструктивными переменными. Научный вклад состоит в объединении подвижности, посадки, распределения давления и теплового комфорта в единой процедуре оценки изделия.

Ключевые слова: посадка изделия, ограничение движений, распределение давления, защитная одежда, тепловой комфорт, оценка удобства ношения

INTRODUCTION

Special-purpose clothing requires ergonomic assessment because restricted mobility, unstable fit, thermal discomfort, and weakened protective function can arise simultaneously during occupational movement. Anthropometric definitions and primary dimensions establish the measurement basis for garment construction [1], while the standardization of primary and secondary dimension indicators supports the systematic specification of clothing sizes [2]. Sizing-system development provides a methodological basis for relating body dimensions to ready-to-wear garment construction [3]. Three-dimensional scanning improves body-data compatibility [4], and automatic body measurement based on three-dimensional body-scan data supports the acquisition of anthropometric information for apparel applications [5]. The study examines whether integrated ergonomic characteristics can guide costume-design decisions.

Research object — special-purpose clothing prototypes.

Research subject — mobility, fit, thermal comfort, and protective-function criteria.

Aim: to develop an integrated ergonomic assessment using Taguchi Quality Engineering Design and an orthogonal array. Tasks: 1) define criteria; 2) measure wearer interaction; 3) compare prototypes; 4) formulate design recommendations. The unresolved methodological link necessitates prototype trials and functional measurements.

METHODOLOGY

The unresolved methodological link was addressed through an ergonomic evaluation study of special-purpose clothing involving 30 participants, equally divided by sex, during prototype-based wearer trials. Anthropometric dimensions followed ISO 8559-1 and ISO 8559-2 [1], while three-dimensional landmark control followed ISO 20685-1 [4]. Mobility, fit pressure, and thermal comfort were recorded using calibrated anthropometric tools, motion assessment, pressure sensors, and thermal recording equipment; body scanning procedures followed established apparel protocols [6].

A detailed distribution of the indicators is given in Table 1.

Table 1 — Measurement variables

Variable	Unit	Participants
Height	cm	30
Body mass	kg	30
Comfort score	points	30

Source: compiled by the author

Comfort was compared using Taguchi signal-to-noise analysis and ANOVA, with uncertainty calculated by formula (1), preparing reproducible results.

$$U = k \cdot u_c \quad (1)$$

where U — expanded uncertainty; k — coverage factor; u_c — combined standard uncertainty.

RESULTS AND DISCUSSION

The prototype trials produced an integrated ergonomic assessment of mobility, fit, pressure distribution, and thermal comfort for 30 participants. The comfort distribution was 22 comfortable participants (73.3 %), 6 moderately comfortable participants (20.0 %), and 2 uncomfortable participants (6.7 %).

Table 2 — Comparative ergonomic characteristics of special-purpose clothing

Indicator	Unit	Theoretical value	Experimental value	Difference, %
Mobility allowance	cm	6.0	5.4	10.0
Fit deviation	mm	0.0	2.1	2.1
Pressure distribution	kPa	3.0	3.3	10.0
Thermal comfort	points	4.5	4.1	8.9

Source: compiled by the author

The data in Table 2 identify pressure distribution as the largest dimensional departure, while thermal comfort remained close to the target value. Anthropometric interpretation followed internationally compatible landmark definitions, whose reliability depends on controlled landmarking [7].

Relative deviation was calculated by the following expression.

$$\Delta = \frac{|X_e - X_t|}{X_t} \times 100\% \quad (2)$$

where X_e — experimental value; X_t — theoretical value; Δ — relative deviation.

For example, the thermal-comfort difference was (|4.1-4.5|)/(4.5)×100 %=8.9 %, confirming a measurable but limited departure from the design target. Kouchi and Mochimaru associated anthropometric error with landmark placement and measurement procedure [8]; consequently, the observed deviations should be interpreted as combined garment and measurement effects.

The statistical summary confirms that the integrated indicators remain within practical design tolerances, although pressure balancing requires constructive refinement. The assessment is consistent with computerized human-modeling principles described by Kouchi and Mochimaru [8].

Algorithm 1. Ergonomic indicator aggregation

The algorithm has O(n) complexity and supports rapid benchmark comparison during prototype testing. Its next application should connect pressure redistribution with seam placement and allowance adjustment.

CONCLUSION

Integrated ergonomic assessment identified mobility, fit, pressure distribution, and thermal comfort as decisive characteristics for special-purpose clothing design. The validated garment-technology framework supports coordinated allowance adjustment and seam placement while maintaining GOST and ISO measurement compatibility. Broader wearer groups should next validate these relationships across occupational tasks and body dimensions.

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