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JUSTIFICATION OF THE ERGONOMIC AND BIOMECHANICAL PARAMETERS OF PREVENTIVE-THERAPEUTIC CLOTHING FOR SCHOOL-AGE CHILDREN

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Abstract: Given that preventive-therapeutic clothing for school-age children maintains prolonged mechanical contact with the body, evaluating its effectiveness solely based on anthropometric fit is insufficient. This article develops a methodology for the comprehensive assessment of ergonomic and biomechanical indicators, using compression and functional therapeutic garments for children as a case study. Based on an analysis of scientific research published between 2020 and 2026, the study examines the interrelationships between contact pressure and its gradient, joint range of motion (ROM), surface electromyography (sEMG), soft tissue vibration, proprioceptive acuity, skin temperature, and subjective comfort. The results indicate that therapeutic efficacy is determined not by maximum pressure, but by a balance between standardized pressure across anatomical zones, physiological freedom of movement, and comfort during use. An integrated model combining anthropometric, pressure, kinematic, neuromuscular, and psychophysiological criteria is proposed for the experimental evaluation of preventive-therapeutic clothing.

Keywords: preventive-therapeutic clothing, ergonomics, biomechanics, compression clothing, contact pressure, ROM, sEMG, proprioception, comfort.

1. INTRODUCTION

Preventive and therapeutic garments for school-age children—including elastic knitwear, products for venous and lymphatic insufficiency, joint and muscle-stabilizing apparel, and functional rehabilitation clothing—must ensure a necessary level of comfort in relation to the human body. Consequently, their quality criteria must encompass not only standard clothing attributes but also fit (body-size compatibility) and the contact mechanics, kinematics, and subjective comfort of the clothing-body system.

Extensive scientific analysis of therapeutic compression garments indicates that biomechanical and neuromuscular outcomes do not always align: while many kinematic and kinetic parameters may remain unchanged, factors such as soft-tissue oscillation, local skin temperature, and certain other indicators do respond to garment pressure [1]. These analyzes demonstrate that optimizing a single parameter is insufficient when designing therapeutic garments.

Therefore, the aim of this study is to systematize the ergonomic and biomechanical parameters of preventive-therapeutic clothing based on modern scientific principles and to develop a set of practical criteria for their experimental evaluation. The study hypothesis posits that therapeutic effectiveness is achieved not through maximum pressure, but rather through the anatomical differentiation of contact pressure, the preservation of range of motion, and the assurance of user comfort.

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2. MATERIALS AND METHODS

In 2020-2026 compression and medical clothes published by scientific research their work comments and materials analytical selected. Retrieved scientific research five to the group separated:

1-anthropometric-constructive compatibility;

2- between clothes and body contact pressure;

3-kinematics and kinetics;

4-neuromuscular and sensorimotor response;

5-thermophysiological and subjective comfort

Contact pressure directly in measurement pneumatic sensors preferably is considered. Experimental in research right on the body surface static and functional actions on time measurement need.

Contact pressure and anatomical differentiation

Healer compression functional in clothes main mechanic parameter interface pressure clothing and body surface between contact pressure is considered. Simplified cylinder in the model pressure Laplace law with is expressed as:

$$P= T/r$$

Here T is the fabric tangential tension, r - surface area of the body local curvature radius. So, a different material and stretching body parts, legs, hips or joint Real pressure in the zones one kind It won't be possible.

Shi Y., Liu R. scientific in the study therapeutic compression in knitwear elastic of threads parameters and the geometric shape of the ring, the pressure noticeable change indicated; suggestion done models geometric indicators approximately 1.1%, pressure and 10.8% deviation with predicted [2]. In 2026, issued hybrid finite-element model and class II compression in socks local tissue descent and thread mechanics separately into account taken from PicoPress to the results ≤20% difference compared with therapeutic ankle > calf gradient again harvest [8]. This information digital a single system in the construction of "material-body geometry-pressure " as look the necessity shows.

Pressure ergonomic border anatomical to zones related There will be 20 people. young in children 2026 study conducted pressure pain threshold and tolerance indicators in work foot along noticeable at the level differentiated; medial and posterior gastrocnemius and sub-popliteal area high sensitivity [3] showed that for the children healer in clothes one flat impact doer pressure not, zoned differential pressure and joint around standard pressure calculating construction to the goal according to.

School- age preventive-therapeutic clothes ergonomic in design main of factors mutual dependence represents. Clothing construction anthropometric to indicators compatibility human movements amplitude, joint corners and step to the parameters directly impact does. Clothes and between the body contact pressure and his/her distribution muscle activity, power and torque indicators with related and they via electromyography (EMG) assessment possible. The material elasticity, toughness, toughness and deformation features and the body of the dress mutual impact and ergonomic convenience. These determines indicators complex assessment therapeutic efficiency saved freedom of movement without and physiological comfort providing optimal preventive and curative clothes construction working to go out opportunity gives. (Figure 1)

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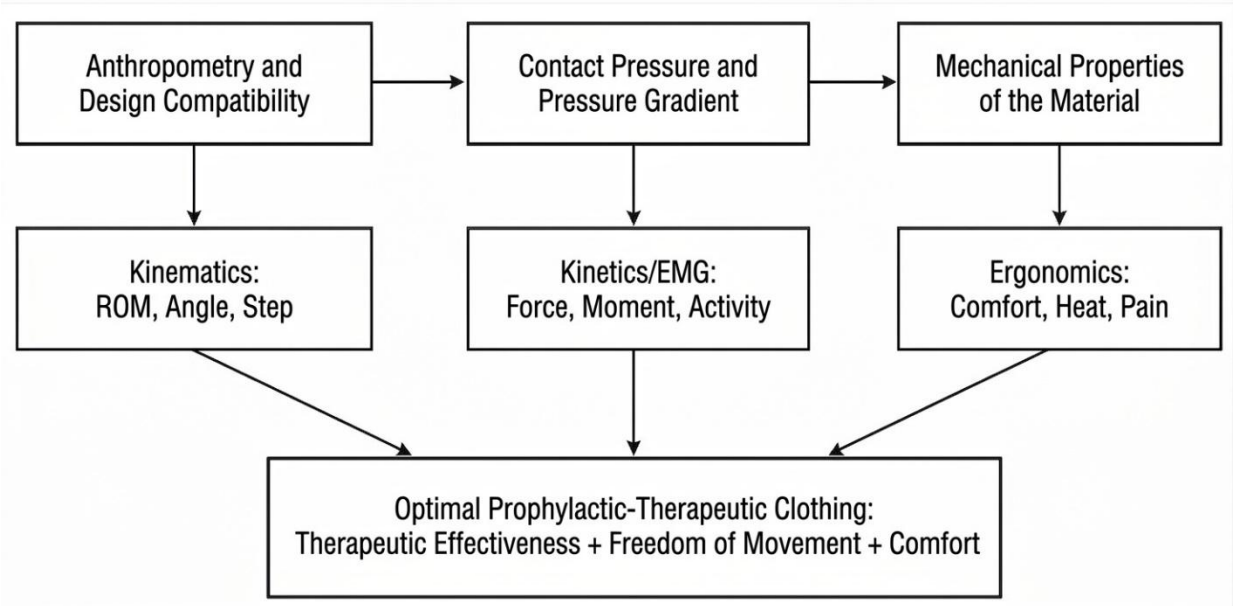


Figure 1. Preventive and curative the clothes ergonomic and biomechanical evaluation integrated model

Range of motion and cinematic compatibility

School- age children preventive-therapeutic of clothes constructive conforms to body contours adhesion with not the physiological amplitude of movement save with evaluated. Whole-leg compression in clothes running biomechanics when studied foot to the ground touch hip flexion in the hip flexion phase decreasing, knee extension increased, muscle synergies The structure has also changed; however bottom extremity moment of the joints and in power directly advantage undefined [4]. This compression clothes neuromuscular coordination changes possible, but every one cinematic interpret change as " improvement " to do possible that it is not shows.

Healer ROM limitation in clothing further important. Bernasconi S., Formichi L. scientific in the study with lymphedema in patients knee maximum flexion healthy 97.7° in the leg, with lymphedema 83.1° on the leg, from multilayer bandaging then it was 70° determined; at the elbow maximum ROM 147° to 130°, wrist 113 ° to 86 ° decreased [5]. So, compression treatment clinical effect daily activity for necessary the amplitude of the movement storage demand with one at the time evaluation necessary.

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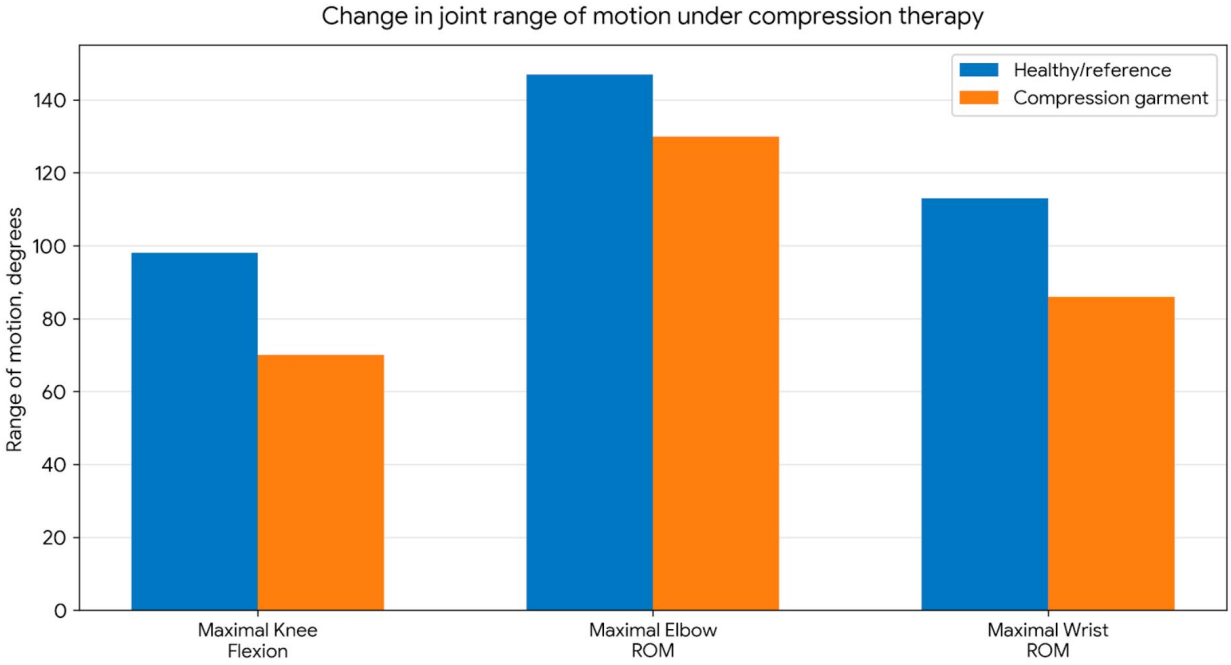


Figure 2. Compression bundle under the circumstances joint ROM indicators decrease ; [5]

School- age children for preventive-therapeutic clothes ergonomic in evaluation child's daily to the activity standing, walking, sitting, using hands up lift, forward and to the side bending movements main functional tests as application This is possible. actions during clothes with the body of the structure compliance, range of motion (ROM) of joints, fabric deformation, local pressure and freedom of movement evaluated. Scientific in research healer compression and functional clothes on the body surface mechanic impact show, some in cases proprioceptive sensitivity and muscles to stabilize help to give [1,6] was determined. Thus together, plus tension or wrong placed constructive elements knee, elbow, shoulder and amplitude of movement in the lumbar region to decrease and to discomfort take arrival possible [7]. Therefore, for children for preventive-therapeutic clothes the movement not limiting, body position physiological in terms of support and pressure anatomical zones according to acceptable distribution necessary.

Children for preventive-therapeutic of clothes ergonomic and constructive compatibility in evaluation applicable main functional situations Standing, walking, sitting, using hands lift, forward and to the side bending in the processes clothing to body movements adaptation, amplitude of movement not limiting and of the material deformation features is evaluated. This actions during shoulder, elbow, waist, hip and knee in the fields to the surface coming stretching, squeezing and contact pressure change identified, clothes construction functionality and ergonomic convenience is evaluated. (Figure 2)

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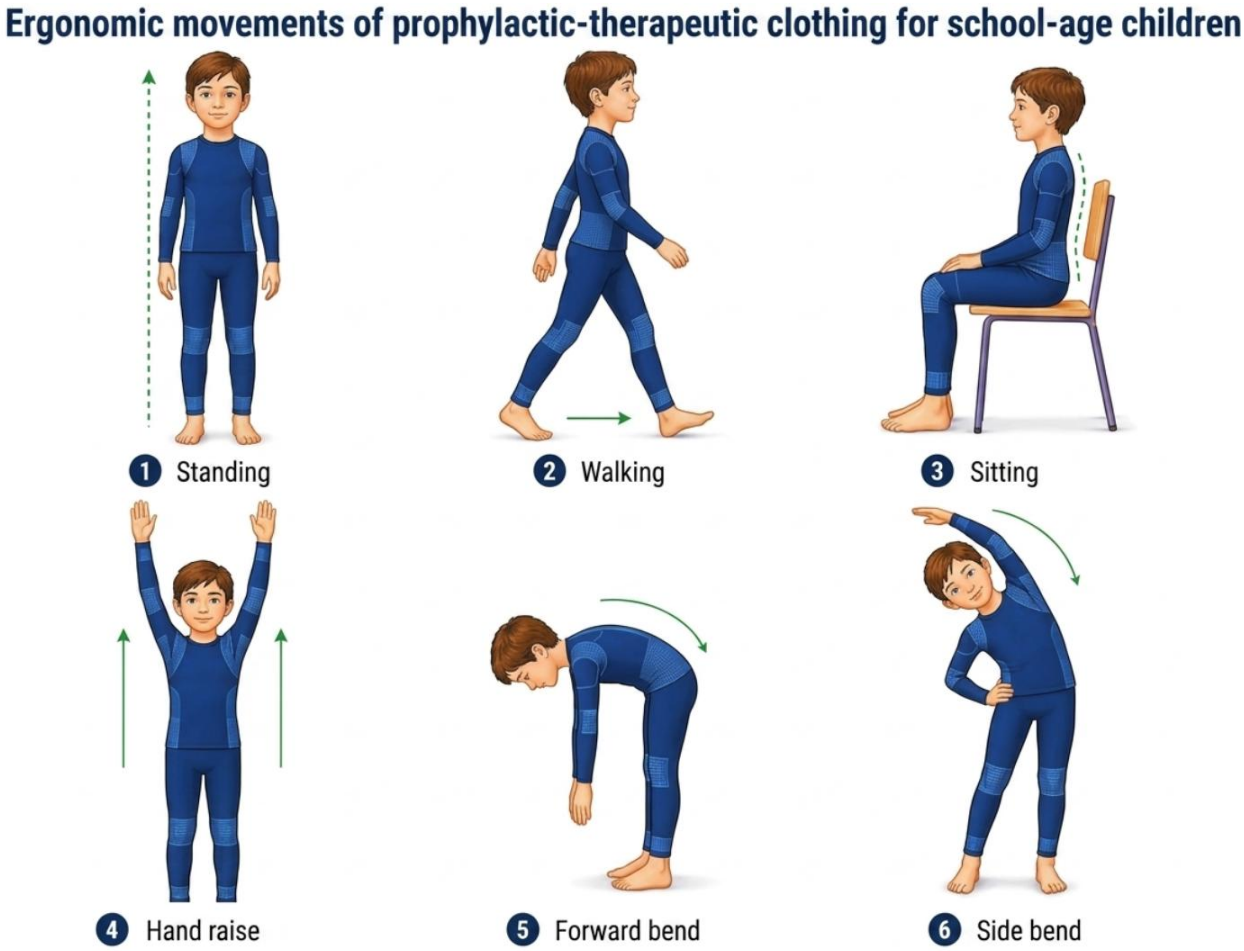


Figure 2. School -age children preventive-therapeutic of clothes main ergonomic in action functional evaluation

Constructive optimization and practical design criteria

First criterion this individualization. Body geometric in the form of differences reason of one nominal size two in the user contact pressure one kind not to be possible. 3D body scanning, parametric slang and finite-element modeling combine through pressure in advance forecast and prototypes number reduce possible [8]. Practical in terms of of clothes goal pressure range, permission done maximum local pressure, minimum ROM retention and comfort borders technician on assignment in advance to be determined need. Then the constructor at work measurable ergonomic-biomechanical to the criteria relies on.

Second criterion thermophysiological comfort. Pressure The stronger the weather exchange decrease and local heat increase possible [1,9,10]. Therefore, for humidity carrier fibers, pores zones, ventilation panels and skin with contact doer soft layers pressure function unbroken without microclimate to manage necessary. In construction flat stitches, stitches pressure sensitive from zones exclusion and to friction inclined at points stitch thickness reducing is also important.

Third criterion action zones liberalization. Joint on top excessive material tension ROM reduce possible; lymphedema and on bandaging cinematic information such limitation daily functional activity for clinically significant to be shows [5]. For this reason, elbow, knee, hip and shoulder joints

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3D anthropometry for and body surface in motion from deformation come outgoing constructive additions application need.

Fourth criterion anatomical zoning. Large muscle in the arrays therapeutic or stabilizing compression enough to be, knee underarm, elbow bend, bone waste and nerve-vessel structures near and local pressure peaks limitation for this purpose various elastic panels, knitwear density change, section lines relocation or pressure distributor soft interface layers through achieve possible 2026 printing sensitivity research various anatomical at points sensitivity differences confirmed because of one kind circular pressure level ergonomic in terms of enough not [9].

Preventive and curative the clothes in design compression level of the material elastic modulus, elongation direction, object detail geometric shape and body surface curvature with together management need. Knitting structure and elastic thread parameters pressure noticeable change possible [6], porosity and material hardness and on the body surface biomechanical strength distribution impact to do shown in [7]. Therefore, the constructive optimization only size reduce or the material stronger stretching through failure to comply need.

CONCLUSION

School- age children preventive-therapeutic of clothes ergonomic and biomechanical efficiency contact pressure, material properties, anthropometric shape, kinematics of movement and subjective convenience mutual connected system as evaluation need. Scientific analyses pressure soft tissues vibration reduces, some under the circumstances proprioceptive accuracy and blood rotation improve possible shows. However, power recovery, kinematics and physiological features according to results one kind not. That's why maximum pressure optimal design criterion be can't.

Integrated approach to individual anthropometry suitable, biomechanical in terms of safe and therapeutic in terms of based children for preventive-therapeutic clothes create for scientific and methodological base become service does.

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