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Basic design parameters to be used in developing hip protective orthosis for the elderly

Yaşlılar için kalça koruyucu ortez geliştirmede kullanılacak temel tasarım parametreleri

Yazar(lar) (Author(s)): *Şükran ÇAKMAK[1], Neşe Yaşar ÇEĞİNDİR[2], Hürriyet Gürsel YILMAZ[3], Mehmet BÜYÜKÇANGA[4]*

ORCID[1]: 0000-0001-5856-2143

ORCID[2]: 0000-0002-8538-9224

ORCID[3]: 0000-0002-7734-806X

ORCID[4]: 0009-0004-9454-577X

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Basic Design Parameters To Be Used In Developing Hip Protective Orthosis For The Elderly

Highlights

- *Hip protectors in preventing hip fractures*
- *Basic design parameters to be considered in developing hip protective orthoses*
- *In hip protective orthoses; material, design, production technology, user comfort and functionality*

Graphical Abstract

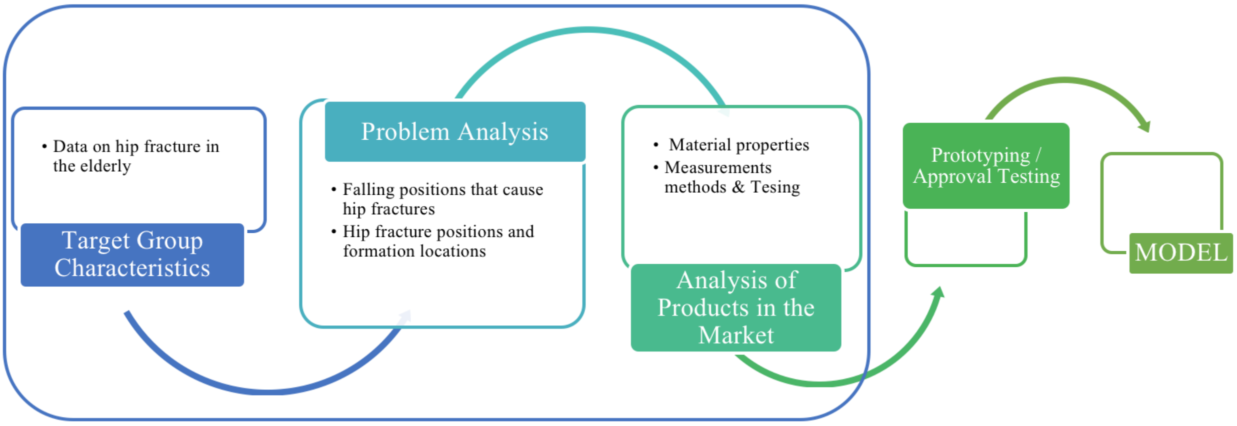

Figure. Research Design

Aim

This study aims to determine the basic design parameters that should be considered in the development of hip protective orthoses for the elderly.

Design & Methodology

The research population in the scanning method is scientific publications obtained from the international literature with the keywords "ageing, posture changes, hip protective orthoses, pads (special purpose clothing to prevent hip fractures due to falls)" and sample hip protective orthosis studies. The research model was carried out according to the preliminary applicability steps of Gupta's functional clothing engineering process, which is enclosed in a rectangle in Figure.

Originality

The study is based on the results of the preliminary feasibility study of the R&D process in line with the objectives of the "Development of an Orthosis Prototype for the Prevention of Hip Fractures" project carried out by the R&D 20-030 University-Industry Collaboration.

Findings

Fall positions that cause hip fractures, hip fracture occurrence locations and design details of hip protective orthoses currently sold in the medical product market were determined.

Conclusion

The basic design parameters to be used in orthoses are determined as: Material, design, production technology, user comfort and functionality.

Declaration of Ethical Standards

The "Development of an Orthosis Prototype for the Prevention of Hip Fractures" project, carried out with the R&D 20-030 University-Industry Collaboration, was carried out with the permission of Ankara Hacı Bayram Veli University Ethics Commission E-11054618-302.08.01-10411

Basic Design Parameters To Be Used In Developing Hip Protective Orthosis For The Elderly

(This study was presented at ART&DESIGN-2022 conference.)

Araştırma Makalesi / Research Article

Sukran CAKMAK[1], Nese Yasar CEGINDIR[2], Hurriyet Gursel YILMAZ[3], Mehmet BUYUKCANGA[4]

[1]Bursa Uludag University, Faculty of Fine Arts, Departmant of Textile and Fashion Design, Bursa, Turkey
[2]Ankara Haci Bayram Veli University, Faculty of Art And Design, Departmant of Fashion Design, Ankara, Turkey
[3]Formed Healthcare, Prosthetic and Orthotic Application and Medical Product, Istanbul, Turkey
[4] Bioaktif Medical Products and Technical Textiles Co. Ltd. Istanbul, Turkey

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ABSTRACT

Fall-related hip fractures are a serious health problem for the elderly. Hip protectors are beneficial in preventing these fractures, but they do limit comfort. According to scientific data, the need for hip protectors is expected to increase in the future due to the growing elderly population.
The aim of this study is to determine the basic design parameters that should be considered in the development of hip protectors for the elderly. For this purpose, firstly, the fall positions and fracture sites that cause hip fractures presented in the studies obtained from the literature review were analyzed. Then, the design and material properties of commercially available orthoses for the same purpose were examined.
The universe of the study where the descriptive method was used; consists of scientific publications made at the international level related to the subject. The design and material properties of orthoses presented in the research results obtained from the literature were taken into the research sample.
These features were evaluated by three different field experts consisting of textile-fashion, physical therapy and rehabilitation specialist and medical product manufacturers and the basic design parameters to be used in hip protective orthoses were determined. These parameters are: Material, design, production technology, user comfort and functionality. In this way, suggestions have been presented that will guide current designs for the development of a national/local health product to support an active, healthy and quality life in line with Türkiye's Sustainable Development Goals.
Keywords: Active and healthy ageing, fall, hip fracture, hip protector, special purpose clothing design

Yaşlılar İçin Kalça Koruyucu Ortez Geliştirmede Kullanılacak Temel Tasarım Parametreleri

ÖZ

Yaşlılarda, düşmeye bağlı kalça kırıkları ciddi sağlık sorunlarına neden olmaktadır. Bu kırıkların önlenmesinde kalça koruyucular avantaj sağlamakta fakat konforlu yaşamı sınırlamaktadırlar. Bilimsel verilere göre gelecekte yaşlı nüfusun artışına bağlı olarak kalça koruyucu ihtiyacının da artış göstereceği öngörülmektedir.
Bu çalışma, yaşlılar için kalça koruyucu ortez geliştirmede dikkate alınması gereken temel tasarım parametrelerini belirlemeyi amaçlamaktadır. Bu amaçla, önce literatür taraması ile ulaşılan araştırmalarda sunulan kalça kırıklarına neden olan düşme pozisyonları ve kırık bölgeleri incelenmiştir. Sonra, bu konuda ticari pazarda aynı amaçla satışı sürdürülen ortezlerin tasarım ve malzeme özellikleri irdelenmiştir.
Betimsel yöntemin kullanıldığı çalışma evrenini; konuyla ilişkili uluslararası düzeyde yapılan bilimsel yayınlar oluşturmaktadır. Araştırma örneklemine literatürden elde edilen araştırma sonuçlarında sunulan ortezlerin tasarım ve malzeme özellikleri alınmıştır. Bu özellikler, ; tekstil-moda, fizik tedavi ve rehabilitasyon uzmanı ile medikal ürün üreticilerinden oluşan üç farklı alan uzmanları tarafından değerlendirilerek kalça koruyucu ortezlerde kullanılacak temel tasarım parametreleri belirlenmiştir. Bu parametreler: Malzeme, tasarım, üretim teknolojisi, kullanıcı konforu ve işlevselliktir. Bu sayede, Türkiye Sürdürülebilir Kalkınma Amaçları doğrultusunda aktif, sağlıklı ve kaliteli yaşamın desteklenmesi için milli/yerli bir sağlık ürünü geliştirilmesine yönelik güncel tasarımlara yön verecek öneriler sunulmuştur.
Anahtar Kelimeler: Aktif ve sağlıklı yaşlanma, düşme, kalça kırığı, kalça koruyucu, özel amaçlı giysi tasarımı.

1. INTRODUCTION

International studies [1; 2; 3] indicate promising strategies to prevent hip fractures in the elderly and to increase the quality of life. The strategies to be implemented to prevent hip fractures are stated as; a) preventing falls, b) improving bone quality with medication and c) reducing the impact force in falls by reducing it below the fracture threshold [4]. The stated strategies have also been adopted by many scientists. When the literature is examined, it is seen that many studies have been conducted to present an international consensus statement to conduct clinical studies on hip protectors [5]. Studies confirm that the strategy of reducing the impact force below the fracture threshold

**Sorumlu Yazar (Corresponding Author)*
e-mail :sukrancakmak@uludag.edu.tr

reduces the risk of hip fractures in the elderly [6; 7; 8]. However, these studies also reveal that hip protector orthoses need to be improved in terms of material, protective effect, comfort, aesthetic appearance, and body fit [9; 10; 11; 12]. Based on this need, a university-industry collaboration project numbered R&D-20-030 was carried out with the aim of developing orthoses to prevent hip fractures in the elderly with local resources. The parameters that emerged in the study are the outputs of the pre-product development feasibility study in this project.

The pre-feasibility study included analyses such as the target audience characteristics and needs required for the prototypes prepared before the company's financial and physical investment decision; technical and legal compliance of the material to be used; manufacturability and marketability of the design. The aim of the study is to determine the basic design criteria that hip protective orthoses should have for active and healthy ageing.

The four questions that will answer this aim are as follows:

1) What are the characteristics of the target group?

2) What are the fall positions and hip fracture locations that cause hip fractures?

3) What are the design details and material features of hip protective orthoses currently sold in the medical product market?

4) What are the user needs and product usability features?

2. METHOD

The research universe in the scanning method is scientific publications obtained from the international literature with the keywords "ageing, postural changes, hip protective orthoses, pads (special purpose clothing for preventing hip fractures due to falls)"; and the sample is hip protective orthoses studies. The research model was carried out according to the pre-feasibility steps of Gupta's [13] functional garment engineering process, which is enclosed in a rectangle in Figure 1.

All three steps progressed with joint interviews of a team consisting of textile-fashion, physical therapy and rehabilitation experts and medical product manufacturers from different disciplines. Firstly, the target group characteristics determined in the studies collected through literature review were determined. Secondly, the fall positions and fracture locations related to hip fractures were determined. In the third stage, the material properties, test criteria and measurement methods of the products available in the market were examined, and in the fourth stage, user needs and product usability features were revealed.

2.1. Data Collection And Evaluation

The data collected through literature review within the scope of the research and the research findings obtained in the R&D studies within the scope of the research were obtained from expert group interviews. The study results examined based on the literature were evaluated by the project group and field experts using the brainstorming technique and visual and physical sample analyses. Considering the features of the existing products, current design parameters for the development of domestic products to support active, healthy and quality ageing in line with the Sustainable Development Goals of Turkey were presented.

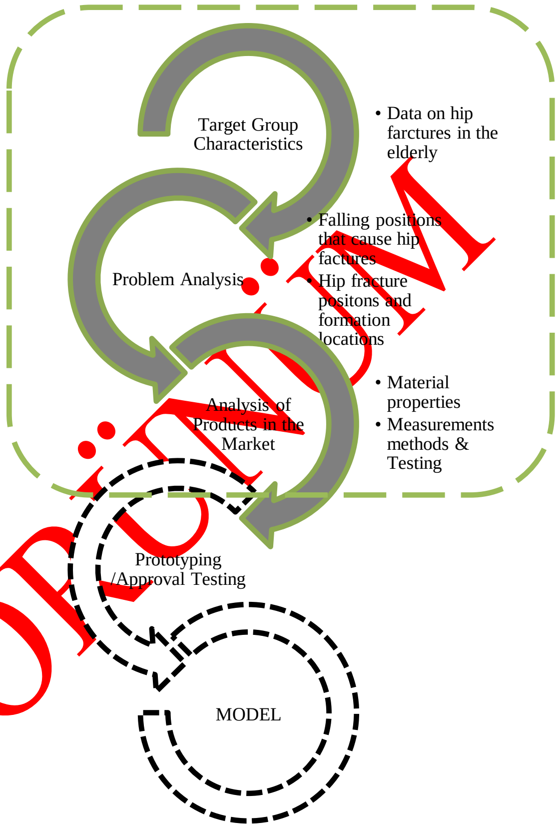

Figure 1. Research Design [13].

3. FINDINGS

3.1. Statistical Data On Target Group Characteristics Regarding Hip Fracture Risk In The Elderly:

According to TÜİK's 2023 data, "the number of individuals aged 65 and over, which constitute 10.2% of the Turkish population, is 3,337,260. 61.8% of this number cannot walk with any help or an assistive device" [14]. Among the primary principles of the Ministry of Health of the Republic of Turkey to protect the health of the elderly, "2/3 of accident-related deaths are caused by falls. approximately 1/3 of the elderly living at home fall at least once every year" [15]. When looking at international data; "50% of the hip fracture burden occurs in disabled and nursing home dependent individuals. Approximately 4 fractures are seen in 100 women per year in nursing homes. Hip fracture risks are seen 10-40 years earlier in people with mental or developmental disabilities compared to the general population. Disability and mortality are common consequences of hip fractures" [16].

As seen in Figure 2, 85% of hip fractures in every age group occur after falls [17; 18]. Between 25% and 75% of individuals with hip fractures cannot perform their pre-fracture mobility functions [19]. The mortality rate seen in one year after the fracture is 20%, permanent disability is 30%, inability to walk independently is 40%, and inability to perform at least one daily living activity independently is 80% [20].

The costs of osteoporosis in terms of causing illness or death, which cannot be fully calculated but are significant, are the costs imposed on the country's social welfare system, such as loss of productivity/income for employees and employers; and increased unemployment/disability-health insurance payments [25; 26; 27; 28]. Table 1 provides a summary table compiled from publications on hip fracture risk factors, fall risk factors and causes of falls in the elderly [15; 29].

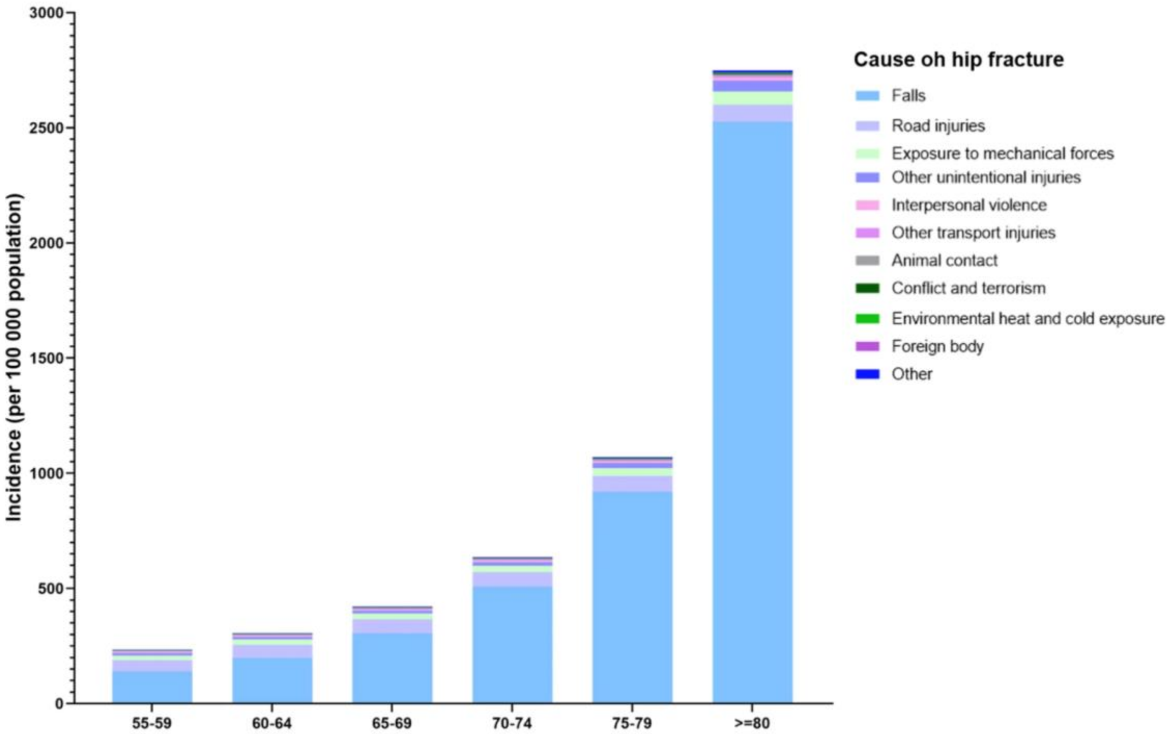

Figure 2. "Cause composition of incidence of hip fracture in patients aged 55 years and older, 2019 (per 100000 population)" [18].

Atamturk's [21] study indicates that the age of 65 is an important turning point in negative changes in body size and proportions. The physiological changes of the body come first among the factors that cause falls. According to Majumder, et al. [6], as the thickness of the trochanteric soft tissue increases, the probability of hip fractures will decrease nonlinearly, as in obese individuals, and it will increase linearly with the increase in hip impact velocity, as in taller individuals, and therefore, it is recommended that preventive measures be considered for thinner and taller elderly individuals. Especially after middle age, factors such as "walking disorders due to musculoskeletal diseases such as osteoarthritis and decreased balance control increase the risk of falls in the elderly. Osteoporosis causes hip fractures, which can lead to disability or death, especially as a result of falls [22; 23]. Osteoporosis affects 200 million women worldwide; at least one vertebral fracture occurs in 1/3 of women over the age of 50. This rate increases to 2/3 in women aged 80 and over [20].

A study by the International Osteoporosis Foundation (IOF) has revealed the high social, economic and human costs to governments of osteoporotic fractures in workers in the EU, Canada and the USA [24].

Table 1. Hip Fracture Risk Factors, Fall Risk Factors and Causes of Falls in the Elderly [15; 29].

Hip Fracture Risk Factors Fall Risk Factors Causes of Falls in the Elderly	Fall Risk Factors	Causes Fall in the Elderly
• Falls • Accidents • Age (>80) • Gender (Being Female) • Weight • Fall Height • Bone Structure • Disability Status • Body Mass Index • Depression • Muscle Weakness • Balance Problems • Gait Disorder • Psychotropic Medication Use • Walking Support Use • Osteoporosis • Arthritis Visual Impairment • Stroke History • Orthostatic Hypotension • Dizziness • Cognitive Impairment Anemia	• Depression • Muscle Weakness • Balance Problems • Gait Disorder • Psychotropic Medication Use • Walking Support Use • Arthritis Visual Impairment • Stoke History • Orthostatic Hypotension • Female Being • Dizziness • Cognitive Impairment	• Individual; 1.General: Decreased postural control, abnormal gait, weakness, visual impairment, decreased reaction time 2.Specific: Arthritis, cerebrovascular disease, Parkinson's disease, cataracts, retinal degeneration, Meniere's disease, blurred vision, syncope, carotid sinus hypersensitivity (with giant cell arthritis), cardiac arrhythmia, epilepsy Vertebrobasilar insufficiency, drugs (Sedatives, hypotensive agents, antidiabetics, Alcohol) • Environmental; Slippery surfaces, bad weather, bad lighting, unusual stairs and floor coverings, tripping toys and objects on the floor, lack of handles in bathrooms and toilets, etc.

3.2. Fall Positions And Fracture Locations Causing Hip Fractures In The Elderly:

According to the research results; The most common fractures are; "36% vertebral, 23% wrist and 23% pelvic fractures" [30]. Hip fracture is associated with the direction of landing during the fall and the body rotation during this process [31]. It has been pointed out that the majority of hip fractures "result from a lateral fall resulting from an impact to the greater trochanter of the proximal femur" [32]. Figure 3 shows radiological images of fractures that occur as a result of sample fall positions in video recordings of elderly cases where biomechanical evaluations of falls resulting in hip fractures were made.

The graph below the same figure provides findings regarding the direction of hip fractures. In the research, it was observed that 100% of hip fracture cases involved falls from standing height and 70% affected the posterolateral aspect of the pelvis. Figure 4a shows the femoral neck fractures, which are the most common regions of hip fractures in the Garden Classification, and Figure 4b shows the pertrochanteric fractures in the AO Classiation.

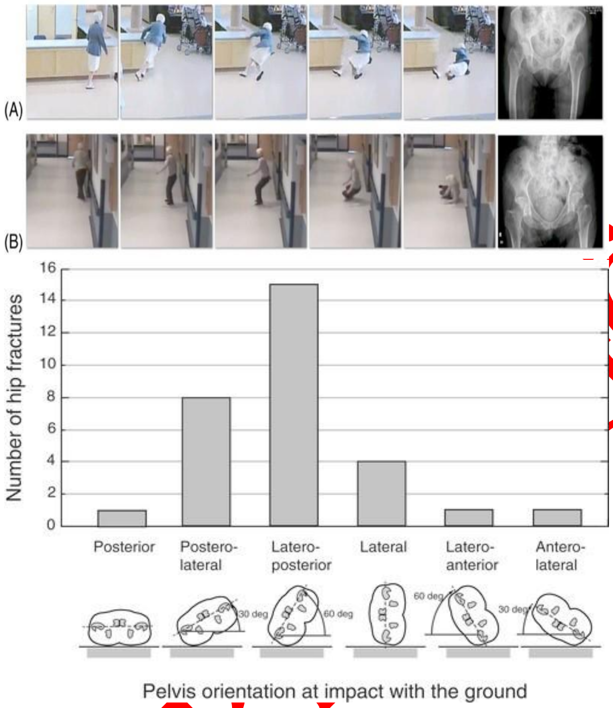

Figure 3. Effect of fall biomechanics on hip fracture risk in older adults [29].

3.3. Design Details And Material Properties of Hip Protector Orthoses Currently Sold In The Medical Product Market:

Within the framework of the strategy of reducing the impact force in a fall by reducing it below the fracture threshold; there are many hip protector products obtained through global scale researches; from small elliptical shaped hard shell structures to large circular soft pads, liquid and air supported materials [34; 35]. In 1993, the results of the first large randomized controlled trial worldwide showed that hip protectors reduce the risk of hip fractures [36]. They are shown as the most cost-effective protection tools in preventing hip fractures [3].

However, researches show that, in addition to design deficiencies, the other most common general problem in hip protectors is compliance [10; 32]. Inadequate acceptance and compliance by elderly people is an obstacle to the use of hip protectors. Design factors that may affect the acceptance and adherence of individuals need to be improved [36].

Studies on compliance have shown that pad material and volume play important roles in changes in thermal comfort properties [37]. Therefore, many test studies have been conducted to improve designs and support comfort. These are studies that reveal the characteristics of biomechanical test criteria of hip protectors with 3D human body shapes or models simulating pelvic anatomy. The first of these was in 2007, when the International Hip Protector Research Group (IHPRG) came together "to address the barriers to the clinical effectiveness of hip protectors and published a consensus statement as Consensus recommendations for conducting future clinical trials of hip protectors" [5]. Figure 5 shows the mechanical properties of hip protector designs of different sizes and shapes sold in the international medical garment market.

Yum, et al. [35] proposed "a hip pad with 6 mm or 8 mm shear thickening polymer (STP) based and 5 mm foam" in their study on the force reduction capacity of material properties. It was revealed that the main factor affecting the force reduction capacity was not the polyurethane foam but the STP. However, it was reported that the foam also played an important role in helping the function of the STP and improving the compliance for the users.

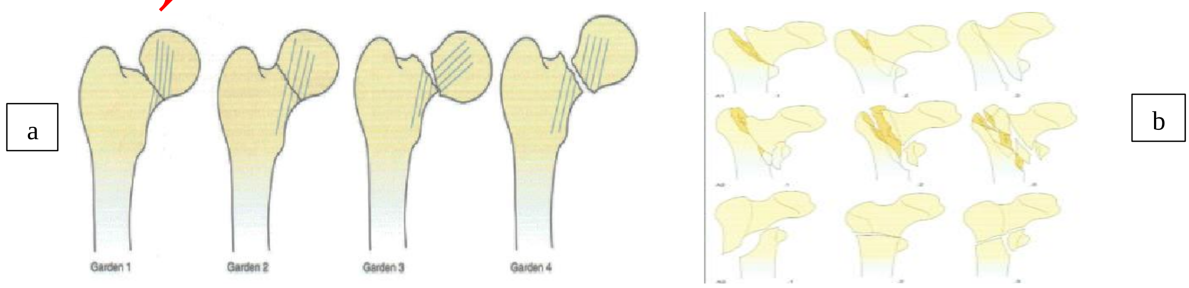

Figure 4. The most common regions and fracture types of hip fractures [33].

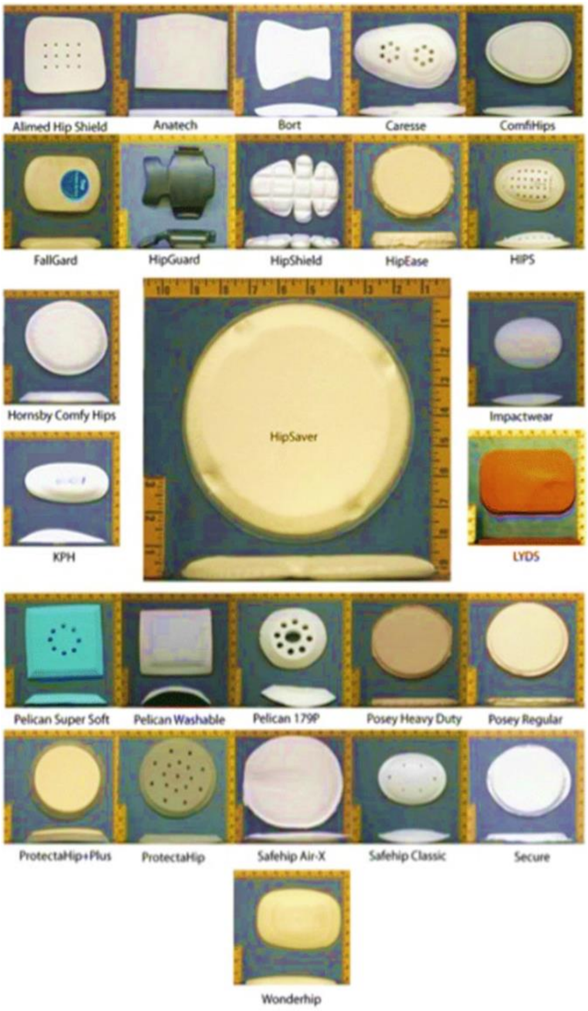

Figure 5. Hip pad designs of different sizes and shapes [38].

Three-dimensional (3D) printing techniques were presented for Impact Reduction Capacity of the 3D Printed Hip Pad [4]. I-Optimal design was used to optimize the important parameters of the hip pad (infill density, shell thickness and material shore stiffness) and the maximum femoral neck force attenuation of the 3D printed hip pad was achieved. The recommended design parameters of the biomechanical testing systems to measure the force reduction provided by the hip pads are given in Table 3.

Pads have different qualities such as perforated/non-perforated, standard/layered, elastic/fixed, soft or hard depending on the design and production technology of the material. In addition, pads designed in various geometric shapes have the ability to take the form of the hip they are placed in and protect it according to the degree of elasticity and softness of the material they are made of.

Figure 6 shows the visual of the position of a sample hip protector orthosis currently on sale on the body according to the position of the femur bone and the parts at risk of fracture. In these products, the hip circumference line (the widest line of the hip) is planned to be the midpoint of the pad.

Table 3. Recommended design parameters of biomechanical test systems for measuring the force attenuation provided by hip protectors [5].

Parameter	Recommended Value or Type
Basic design	Impact pendulum or drop tower
Effective (drop) mass	28 kg (acceptable range, 22-33kg)
Effective pelvic stiffness	47 kN/m (acceptable range, 39-55kN/m)
Soft issue covering	Polyethylene or polyurethane foam rubber
Minimal thickness of soft tissue over the trochanter	18mm
Impact velocity	3.4 m/sb
Peak compressive force in unpadded case	3.5-4.5 kNc
Time to peak compressive force in unpadded case	30-50 ms
Filtering of force signals	Low pass recursive, cut off frequency=50 Hz

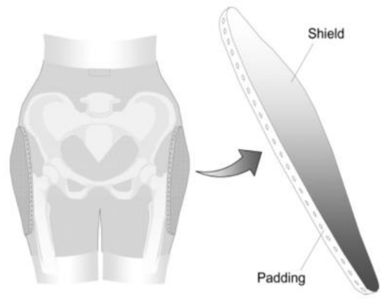

Figure 6. Position of the hip protector orthosis sold in the medical clothing market on the body [32].

Derler et al. [39] determined that the most accurate position of the protector in reducing the loads that cause femur fracture is provided with a horizontal 10° incli nation and a posterior 12° placement.

Hong and Lee [12] designed three different types of hip protector orthosis based on snowboarding movements and three-dimensional male body scans. Six types of pads prepared in three dimensions were tested by user subjects. In terms of freedom of hip and groin movements, body fit, and shock absorption, the original pad was evaluated negatively, and the open-outside and inside type pad was evaluated positively (Figure 7). The results showed that three-dimensional and printed thermoplastic polyurethane (TPU) pad + ethylene-vinyl acetate (EVA) foam or only EVA foam are the most commonly used materials in such pads.

Most of the studies have examined the material thickness, weight, hardness, etc. of existing hip protectors. Laing, et al. [38]; It is revealed that "hard materials have a greater force reduction effect (27%), but the force reduction value varies according to the impact velocity, pelvic size, and pelvic soft tissue hardness".

Figure 7. Hip pads compatible with groin movement sold in the medical clothing market [12].

Table 4 compares the features of hip protective orthoses sold in the medical clothing market [35]. The thicknesses of eight different orthoses vary between 14 mm and 21 mm; their weights range from 21.6 g to 103.4 g. except for one, all have a soft mechanism.

Table 4. Features of hip protective orthoses sold in the medical clothing market [35].

Hip Protector Orthosis	Thinness (mm)	Weight (g) Mechanism	Weight (g) Mechanism
Pelican (C1)	22	33.1	Soft
Posey (C2)	14	21.6	Soft
Safe Hip (Ce3)	16	35.6	Soft
Hornsby	18	103.4	Soft
Fall Safe (C6)	19	65.6	Soft
Hip Saver (C6)	16.5	43.8	Soft
Impact Wear (Hard C7)	4	26.9	Hard
Impact Wear (Soft C8)	16	72.4	Soft

3.4. User Needs and Product Usability Features

It is known that wearable hip protectors reduce the risk of fractures by up to 80% when worn during falls for older adults [40]. However, studies have shown that "design deficiencies", inadequate acceptance and compliance by older people are obstacles to the use of hip protectors [10; 32]. For example; 24-hour compliance rate was 29%: 37% during the day and 3% at night [41]. In another study, compliance was determined as approximately 53% during the study period [42]. Therefore, design factors that can affect user acceptance and commitment need to be developed [36].

When international studies that will reveal basic design criteria for the development of design factors are examined; User requirements for functional designs are examined under four subheadings as physiological, biomechanical, ergonomic and psychological requirements [13].

When physiological requirements are examined, it includes elements related to the functioning of the mechanical, physical and biochemical functions and systems of the human body [43]. The human body has a biomechanically dynamic structure. For this reason, in clothing construction, the dynamic measurements of the body must be taken into account in addition to the static measurements [44]. Anthropometric data are needed for designers to design products that will facilitate the lives of elderly consumers [45]. For this purpose, movement studies and pad position studies are carried out using different experimental methods [34]. For the evaluation in standing and sitting positions, the fit and comfort of use of the pad in the general region, the hip region and the sides of the hips are evaluated [46].

In clinical applications for the ergonomic fit of hip protectors; Hip protective pads with different features sold in the medical clothing market are ergonomically; comfort, fit, movement comfort and groin movement adaptation were evaluated on the subjects, and it was seen that the pad design features were effective in affecting comfort [12]. In terms of clothing, these ergonomic requirements can be defined as the whole of multidimensional relationships between humans and clothing [44]. For example; Hip protective pad designs, in terms of physiological and ergonomic comfort, using 3D human body shapes and considering snowboarding movements in accordance with the intended use [12] is an effective method in meeting ergonomic requirements.

Psychological needs in the design processes gain meaning in terms of expressing a hedonically value by the consumer. Hedonic value, as a consumption behavior, is "the consumer behavior characteristics that the individual creates through product experience, based on emotional arousal with multiple images such as pleasure, sound, taste, smell, tactile and visual impressions" [47].

In functional clothing, the focus is on product comfort, ease of maintenance and protective performance parameters within the framework of user needs [44]. It has been shown that the performance characteristics of hip protective clothing related to thermal clothing comfort are affected by the material, volume, thickness, size and fabric structure of the pad (37). In summary, user needs are the criteria that determine product usability features; design and material features are the criteria that determine functionality and the adaptation process.

4. CONCLUSION AND RECOMMENDATIONS

1.5 million people worldwide experience hip fractures due to falls each year; "it is predicted that 21.3 million people will have hip fractures each year globally by 2050" [20]. Studies have shown that the average age in the world and in Turkey is increasing, and the risk of hip fractures is increasing due to old age. This data is also supported by studies on the epidemiology of hip fractures [25; 48; 49; 50]. Hip fractures are considered a worldwide epidemic and a major public health concern [16].

Hip fracture cases can be seen in falls that occur at least from standing height. Hip fractures that occur for various reasons cause individuals to remain isolated from social and economic life. Expenses for treatment put a greater burden on state budgets than preventive health services [18; 51; 52]. Increasing preventive measures for healthy and active ageing will also contribute to less burden on state budgets. Since the first large randomized controlled trial worldwide in 1993 [53], many research results have emphasized the importance of hip protectors in reducing hip fractures in the elderly and have shown that hip protectors are a measure used to prevent hip fractures. These data also highlight the importance of design criteria in specialty clothing for active and healthy ageing.

In light of this data, in expert group interviews based on the research findings obtained in the existing meta-analyses, cohort studies [8; 16; 29; 54] and R&D studies within the scope of the research, the design parameters required for the development of hip protective orthoses for elderly individuals were collected under the titles of "material, design, production technology, user comfort and functionality".

Material is a feature that directly affects the production method and other design parameters. The materials to be used in hip protective orthoses must meet ergonomics and functionality. Although hard materials are more effective in absorbing impact, flexible structures provide ease of movement. Soft ones support comfort positively by adapting to the user's body lines and grasping. The soft and flexible pads in the latest study are a positive development for the elderly who spend most of their time in a sitting position due to the slowdown in their movements. The soft and malleable properties of the materials are promising for future R&D studies. It is anticipated that products prepared from such materials will be easier to be accepted by the elderly.

According to the findings examined, in the design criteria in the R&D process; both harmony that will support ergonomics and usability and positioning features that will support functionality have been determined as two important headings. Harmony in design supports sub-criteria such as the physical structure of the product (size, weight, etc.), meeting user expectations with its aesthetic appearance and supporting ergonomic usability. Another criterion that will support the functionality of the design is positioning. Research shows that, [39] the most accurate position of the pads for protecting the femur bone should be the placement with a "horizontal 10° inclination and posterior 12°" angle. This position will provide ergonomic use to individuals; perforated, cut, flexible and multi-layered designs will offer more comfort compared to standard models.

As a result, by using the ever-evolving production technology, it is possible to highlight product value and aesthetics, especially functionality. Thus, by developing lighter and more effective product designs; user comfort and long-term product usability can be supported. It is recommended that the criteria for engineering applications given above be taken into consideration for the design of hip protective clothing, where maximizing protection is critical. It is thought that the data obtained from this research will be a guiding guide for health, sports and daily protective product designers. In addition, the studies clearly demonstrate the necessity of hip protective orthoses as well as personalized fall prevention interventions developed to reduce the fall rates of individuals [55].

This study is based on the results of the preliminary feasibility study of the R&D process in line with the objectives of the "Development of Orthosis Prototype for Preventing Hip Fractures" project carried out with the R&D 20-030 University-Industry Collaboration. The testing stages of the Orthosis prototype obtained from the R&D studies of the project continue according to the determined design parameters.

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DECLARATION OF ETHICAL STANDARDS

The "Development of an Orthosis Prototype for the Prevention of Hip Fractures" project, carried out with the R&D 20-030 University-Industry Collaboration, was carried out with the permission of Ankara Haci Bayram Veli University Ethics Commission E-11054618-302.08.01-10411

AUTHORS' CONTRIBUTIONS

Sukran CAKMAK: Write the manuscript and analysis the results.

Nese Yasar CEGINDIR: Write the manuscript and analysis the results.

Hurriyet Gursel YILMAZ: Collection and analysis of data on medical issues.

Mehmet BUYUKCANGA: Orthosis production methods and collection of data on the market.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

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