

Designing better hip protectors: a critical and contextual review examining their acceptance and adoption in older populations

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Abstract: Hip fractures are a very serious condition in the elderly, greatly increasing morbidity and mortality. Hip protector garments, with integrated impact absorbing or deflecting pads, are known to help reduce hip fractures when worn by high-risk populations. However, uptake of these products is low. By investigating academic studies and sales and marketing literature, this paper provides a critical and contextual review of barriers to acceptance and adoption of hip protectors amongst older adults. This is part of a broader PhD investigation to establish how hip protection can be improved through human-centred design. Discomfort is the most reported barrier to acceptance although there are several more, including aesthetics and difficulty of use. Receptivity towards hip protectors is key to eventual compliance, and design criteria including aesthetics, convenience, comfort and cost should be as important as the level of impact protection to the hip joint.

Keywords: Hip Protector, Hip Fracture, Elderly, Garment Design, Human-Centred Design

1. Introduction

This research represents the early stages of a PhD project examining falls in the elderly, in particular investigating the opportunities for improved forms of hip protection design. The study will inform the development of prototypes to understand how hip protection can be designed to look, feel and operate, in a way that is sensitive to sociocultural and lifestyle aspirations of elderly people, whilst reducing the risk of hip fractures caused by falls. Human-centred design will directly engage with people who are potential users of the product to inform the design development. In addition to understanding pragmatic requirements, a design language will stem from this research that embraces the reflective meaning perceived by users towards hip protectors. A human-centred approach will shift the emphasis of design intent beyond the technology-centred design language of current products.

In order to understand the opportunities for improving the design of hip protectors, this paper reports on a critical and contextual review focusing on the acceptance and adoption of current available products for elderly populations. The aim of this review is to establish appropriate themes for enquiry within a human-centred design research context. This secondary research, and later primary research, will define the design opportunity and inform a design brief for new product development.

2. Context

Hip fractures are a major cause of long-term disability and can lead to a rapid shortening of healthy life years for older people. The average age of a person who fractures their hip is 77 years, demonstrating it is not only the very old who are at risk (National Clinical Guideline Centre, 2011). More than 90% of hip fractures occur as a result of a fall (Norton, Campbell, Lee-Joe, & Robinson, 1997), primarily when a person lands on their side and the impact force against the floor causes a break near the femoral neck (the section between the top of the femur and the 'ball joint' of the hip). Sideways falls increase hip fracture risk by 5-fold when compared to forward or backwards falls (Hayes, Myers, Morris, & Gerhart, 1993). Crucially, however, this risk increases by 32-fold when direct impact to the greater trochanter (the bony protuberance at the top of the femur) occurs (Nevitt & Cummings, 1993).

Elderly residents in nursing homes, or similar long-term care facilities, are most at risk of fracturing a hip. Tideiksaar (1997) claims that up to 50% of residents in nursing homes experience a fall every year, and that over 40% experience more than one fall. About 4% of these populations experience hip fracture every year (Chandler, Zimmerman, Girman, & Martin, 2000; Lauritzen, 1997; Singh, Sun, & Anis, 2004), which is up to 10.5 times greater than community dwelling elderly populations (Butler, Norton, Lee-Joe, & Cheng, 1996; Norton, Campbell, Reid, & Butler, 1999). An explanation for this trend is the tendency for long-term care residents to suffer from more chronic illness and mobility difficulties than their counterparts still living in their own homes. Indeed, Boonen, Autier, Barette, and Vanderschueren (2004) show that 20% of elderly community dwellers who survive a hip fracture have to move to a care home because of the disability and functional impairment the fracture brings. Magaziner, Hawkes, Hebel, and Zimmerman (2000) show that among hip fracture survivors, over 80% reported needing assistance bathing or to climb five stairs at both 12 and 24 months post-fracture. Further to the chronic morbidity that can be caused by hip fractures, approximately 20% of people who experience a hip fracture die within one year of the injury occurring (Leibson, Tosteson, Gabriel, & Ransom, 2002).

Women are statistically four times more likely to suffer a hip fracture than men (Parker, Gillespie, & Gillespie, 2006) due to higher instances of osteoporosis and longer life expectancy. However, by 2050 it is expected that this trend will reverse and annual occurrences of hip fracture will be greater in men due to an overall increase in elderly population and changes in demographics (Bleibler, Konnopka, Benzinger, & Rapp, 2013). The annual cost of medical and social care for all the hip fracture cases in the UK amounts to about £2 billion (National Clinical Guideline Centre, 2011). In the US, where there are approximately 150,000 hip fractures per year, the estimated cost of care is between \$10.3 billion and \$15.2 billion (Burge, Dawson-Hughes, Solomon, & Wong, 2007; Gillespie, 2001). The total number of hip fractures worldwide is predicted to rise from 1.6 million to 6.2 million by 2050 if no action is taken to reduce this growing health crisis (Kannus, Niemi, Parkkari, & Palvanen, 1999).

Hip protectors are an effective way of reducing the risk of hip fracture (Lauritzen, Petersen, & Lund, 1993). There are at least 26 different hip protectors commercially available (Laing, Feldman, Jalili, & Tsai, 2011). The most common hip protector designs comprise of underwear containing integrated or removable pads that provide impact protection over the greater trochanter region of the hip joint. Two main types of protective pad are predominantly found: soft, foam shock-absorbing pads (see Figure 1), or rigid plastic shells that deflect energy on impact. Although some designs make small concessions to gendered styling, most of the underwear products are available, or marketed, as unisex.



Figure 1. Fall Safe hip protector underwear shown with left hand shock absorbing pad removed from internal pocket (author's own photo).

Numerous hip protector patents were registered in the mid-nineties as the market grew, however, little innovation and development of these designs has been seen since then. In a systematic review of studies examining acceptance and adherence to hip protectors, Korall et al. (2015) note that, “despite improvements in the design of hip protectors over the last decade, we observed that discomfort, unwanted side effects, and poor ergonomics (e.g. complexity of use) persist as substantial barriers to their continued use.” The effectiveness of reducing hip fracture risk when wearing hip protectors is well reported, especially in long term care contexts. For example, Hubacher and Wettstein (2001) report that 50% of all hip fractures can be prevented if hip protectors are worn. They assert, “that the percentage of preventable hip fractures is not higher is not due to any shortcomings in the mechanical protective effect of hip protectors but to insufficient willingness to wear them on the part of fall-prone senior citizens”. Many studies report that participants find hip

protectors uncomfortable or dislike the way they look, which can negatively impact on the clinical effectiveness of intervention studies using hip protectors due to lack of compliance and limited 'wearing time' (Kurrle, Cameron, Quine, & Cumming, 2004).

Hip protectors that use inflatable technologies are now emerging with at least four start-up companies bringing new products to market. An airbag system, deployed from a belt, negates the need for bulky padding on the hips, overcoming some of the problems reported with underwear products. The Wolk, for example, uses inertial sensors to detect falls happening and automatically deploys airbags over the hips (Wolk, 2018). However, the initial cost, and ongoing 'recharge' cost for these types of products presents a significantly higher financial outlay than traditional hip protectors. Cianferotti, Fossi, and Brandi (2015) note that these types of devices could significantly improve comfort, therefore increasing compliance. However, the authors make reference to the International Hip Protector Study Group (IHPSG) recommendation that economic analysis should be included in future clinical trials of hip protectors (Cameron, Robinovitch, Birge, & Kannus, 2010).

The seriousness of hip fractures and devastating impacts on the health and wellbeing of elderly people, demonstrates the need for more effective fall prevention and protection interventions. The shortcomings of current hip protector designs are well established and explored in detail later in this paper. Although new airbag designs seek to provide more comfortable and discreet hip protection, this high technology solution potentially overlooks other critical user needs, perhaps alienating some elderly people at risk from falls.

3. Methodology

The research methodologies adopted align with the early stages of the PhD project investigating human-centred design methods to develop more widely accepted hip protector products. The Design Council's double-diamond methodology (Design Council, 2015) provides an established structure to frame the overall PhD investigation within four phases: discover, define, develop and deliver (see Figure 2). This paper reflects on the desk-based research established through the 'discover' phase, identifying precedents to evaluate opportunities for improvement, guiding concept development and prototyping. New knowledge will exist in the junction between technological innovation, inclusive design, fashion theory and product semantics, proposing new solutions to reducing hip fractures in the elderly. The practice will test theory in these domains to develop human-centred design solutions in response to technology-centred hip protector precedents.

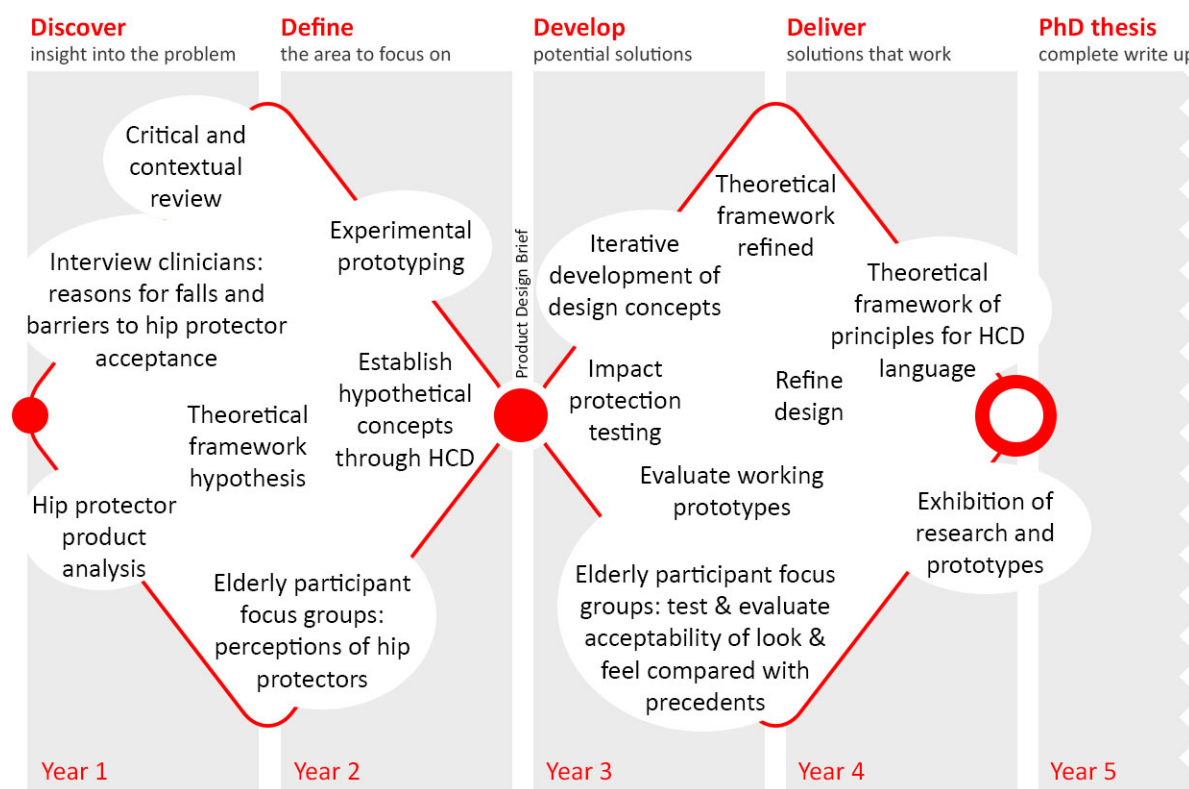


Figure 2. Summarised version of the PhD structure adopting the Design Council's double-diamond methodology. Adapted from Design Council (2015).

3.1 Review of studies into acceptance and compliance with hip protectors

An initial search of academic journal articles was conducted using a combination of terms, including “hip protection”, “hip protector”, “elderly”, and “design”, with no constraints on year of publication. The particular focus of the investigation was on studies where acceptance and compliance issues were examined. However, further reading relating to falls in the elderly and hip fracture prevention naturally occurred as part of the broader investigation. Two systematic reviews of literature were identified: van Schoor, Devillé, Bouter, and Lips (2002) and Korall et al. (2015). Their findings provided useful insights but also a means of cross-referencing articles already reviewed and highlighting other important studies not yet read. Barriers to acceptance and adherence were established across the review and the articles were categorised accordingly to establish the frequency of reported barriers. Several studies of care home populations report on system barriers, such as level of staff training and commitment to hip protector use (e.g. Burl, Centola, Bonner, & Burque, 2003; Cryer, Knox, Martin, Barlow, & Canterbury hip protector project team, 2002; Cryer, Knox, & Stevenson, 2006; Doherty, Glover, Davies, & Johnson, 2004; Forsén, Sandvig, Schuller, & Søgaaard, 2004; Hubacher & Wettstein, 2001; Tavener-Smith & De Vet, 2006; Thompson, Jones, Dawson, & Thomas, 2005; van Schoor, Asma, Smit, & Bouter, 2003; Warnke, Meyer, Bender, & Mühlhauser, 2004). However, this paper only focuses on the barriers perceived by users associated with the design of hip protectors.

3.2 Analysis of hip protector market and garment design

The literature review was supported by a wider review of the market for hip protector products. Internet searches, adopting the same search terms as the literature review, provided a quick and

accessible way to establish key manufacturers, online retailers, and specific hip protector designs. The visual representation of products through sales images was of particular interest in relation to initial acceptance, and observations across a range of marketing material are reported on later. Further desk research into academic sources underpinned these observations.

3.3 Analysis of retail cost of hip protectors in relation to appearance and performance.

Further to the broader market review, a more systematic approach was also adopted. Laing et al. (2011) studied the effects of pad geometry and material properties on the biomechanical effectiveness of 26 commercially available hip protectors. The products they chose were representative of a range of different styles of hip protector garments. However, the study focused only on the force attenuation properties of the protective hip pad element, and did not analyse the respective garment. With reference to their study, the same 26 hip protector products were independently reviewed through the available online marketing material to correlate aesthetics and retail cost (two key factors influencing acceptance) with the biomechanical effectiveness reported by Laing and colleagues.

4. Findings

The most notable observation from this research is the positioning of hip protectors as a medical intervention as opposed to a consumer product. This finding reflects Pullin's (2009) recognition of the significant cultural differences found between product design and medical engineering. In this respect, the discourse concerning the design of hip protectors sits firmly within literature from the fields of medicine, nursing and gerontology. For example, Cianferotti et al. (2015) and Laing et al. (2011), assert that aesthetic considerations, are secondary to the biomechanical properties of hip protector design. Here the primary focus is on principles of engineering relating to shock-absorbing, or deflecting, materials that provide the optimum conditions to reduce the risk of hip fracture. Watkins and Dunne, (2015), whose expertise is in functional clothing design and broader classifications of protective garments, suggest a more intuitive approach:

A garment cannot provide protection if it lies on a shelf. The designer's most difficult job is to design *acceptable* protective forms. The perfect protective garment would involve no trade-offs - it would meet an individual's physical *and* psychological needs. The ideal is often impossible to reach, so designers must work to maximise the degree to which each need can be met. (Watkins & Dunne, 2015, p. 254)

Within the published literature, no peer reviewed articles concerning the design of hip protectors were found in any journals related to product or garment design, or human centred design practice. Similarly, the market review suggests that existing hip protector products are generally marketed through organisations that specialise in mobility aids and assistive technologies, mostly targeting concerned relatives or institutions purchasing in volume. This presents a clear opportunity for the development of new insights into hip protector design and human centred research methodologies, and equally sets an agenda for better designed products aligned with lifestyle aspirations of older people.

4.1 Hip protector acceptance and compliance

Six key barriers to acceptance and compliance are identified by Sims-Gould, McKay, Feldman, Scott, and Robinovitch (2014) that are broadly reflected in the studies reviewed (see Table 1).

Table 1. Six key barriers to hip protector acceptance and compliance. Expanded from Sims-Gould et al. (2014).

Key Barriers	No. of studies identified where barrier is listed	Reference citations
Discomfort	18	Bentzen, Forsén, Becker, & Bergland, 2008a; Bentzen, Bergland, & Forsén, 2008b; Blalock et al., 2010; Burl et al., 2003; Cameron et al., 2011; Cryer et al., 2002; Doherty et al., 2004; Honkanen et al., 2006; Hubacher & Wettstein, 2001; Ledsham, Boote, Kirkland, & Davies, 2006; Milisen, Coussement, Boonen, & Geeraerts, 2011; Myers et al., 1995; O'Halloran et al., 2007; Patel et al., 2003; Sawka, Nixon, Giangregorio, & Thabane, 2007; Tavener-Smith & De Vet, 2006; Thompson et al., 2005; Woo, Sum, Yiu, & Ip, 2003
Dislike of appearance	9	Blalock, Demby, McCulloch, & Stevens, 2010; Cameron, Kurrle, Quine, & Sambrook, 2011; Chan, 2000; Forsén et al., 2004; Honkanen, Dehner, & Lachs, 2006; Hubacher & Wettstein, 2001; Myers, Michelson, Van Natta, Cox, & Jinnah, 1995; Patel, Ogunremi, & Chinappen, 2003; Thompson et al., 2005
Difficulty of use (getting on and off due to physical frailty)	9	Bentzen et al., 2008b; Chan, 2000; Doherty et al., 2004; Forsén et al., 2004; Ledsham et al., 2006; O'Halloran et al., 2007; Patel et al., 2003; Tavener-Smith & De Vet, 2006; Woo et al., 2003
Development of unwanted side effects such as heat rash	8	Bentzen et al., 2008a; Bentzen et al., 2008b; Blalock et al., 2010; Doherty et al., 2004; Forsén et al., 2004; Ledsham et al., 2006; Milisen et al., 2011; Tavener-Smith & De Vet, 2006
Loss of independence, especially related to using the toilet	4	Blalock et al., 2010; O'Halloran et al., 2007; Parkkari, Heikkilä, & Kannus, 1998; Tavener-Smith & De Vet, 2006
A lack of understanding and acceptance of fracture risk	4	Chan, 2000; Doherty et al., 2004; Milisen et al., 2011; Patel et al., 2003

These themes offer key points of enquiry for further empirical research, and provide useful criteria to inform a design brief for new product development. Across the studies reviewed, issues relating to discomfort, dislike of appearance and difficulty of use, appear to be the most commonly reported barriers to long-term acceptance.

Discomfort relates to hip protectors being generally uncomfortable to wear, with extreme discomfort and pain observed if the product causes unwanted side effects such as heat rash. Patel et al. (2003) found, of the 62% of women who refused to wear the protectors for their study, the highest proportion (34%) said that it was because they were uncomfortable. Tight fitting underwear - and the potential for outer garments to feel tighter as the protective pads increase the hip width - can feel more uncomfortable sitting down, than standing up (Blalock et al., 2010). Similarly, users could

be more aware of feeling the hip protectors when walking rather than at rest. Wearing hip protectors in bed might be uncomfortable, particularly if the user is trying to sleep on their side (Ledsham et al., 2006). When interviewing care home residents, Doherty et al. (2004) reported that comfort emerged as the most important consideration. They found that the hard shell protectors dug in and rubbed, causing discomfort. A resident described the hard shell as, “like a piece of plaster, a piece of a building [...] it was hard and uncomfortable. It rubbed...”.

Dislike of appearance is two-fold: negative perceptions towards the overall look of the product and a dislike of personal appearance when wearing them. The fundamental requirement to protect the greater trochanter naturally requires a certain thickness of material (shock absorbing or energy shunting) to be placed over this area. The visual bulkiness of this padding certainly contributes to the dislike of personal appearance, as demonstrated through participant feedback gathered by Sims-Gould et al. (2014). In an interview, a resident commented that, “if they’re wearing slacks, they bulge out the side of the slacks, and it doesn’t look pretty”. Another resident was more scathing, adding, “It’s making you look bigger than what you are. Those things look hideous on some people”. The authors observed staff awareness of the aesthetic issues too, noting that female staff, in particular, could see the concerns for older women who felt that hip protectors made their hips look wider and overweight. Doherty et al. (2004) also noted that female care home residents were put off by the masculine appearance of underwear hip protectors.

Tavener-Smith and De Vet (2006) conducted in-depth interviews with hospital outpatients prescribed hip protectors. They found the most prevalent theme was that underwear hip protectors were perceived as a garment of clothing worn within domestic routines of getting dressed, using the bathroom, and other ordinary daily activities. In this respect, physical frailty makes usage difficult. An 83 year old lady commented, “I found them very difficult to put on. I couldn’t get them up. I did manage to push them down to get them off, this is the main issue with me”. The difficulty associated with putting on and taking off hip protectors can impact on the independence and autonomy of the user. Care home residents who were otherwise able to use the toilet independently found that they couldn’t when wearing hip protectors (Ledsham et al., 2006; O’Halloran et al., 2007). Van Schoor et al. (2002) identified studies where hip protectors have actually contributed to falls for this very reason. For example, Cameron and Kurrle (1997) reported on a woman with Alzheimer's who suffered a hip fracture after falling whilst trying to use the toilet during the night. The hip protector appeared to be around her knees at the time.

The practical aspect of underwear holding the protective pad closely to the hip cannot be ignored but the attempt to hide the protection under clothing perhaps also reflects a perceived sense of embarrassment or shame linked to ageing and loss of independence. This perception may also contribute to a lack of understanding or acceptance of fracture risk, where elderly people are not prepared to accept the need to wear hip protectors. Sims-Gould et al. (2014) note that even care home residents who appear frail don’t recognise the need in themselves. However, they are able to recognise other residents who are very frail and unsteady and “really need them”. This illustrates how hip protectors are synonymous with increased dependency and frailty for those who wear them, and naturally there is reluctance to be identified within that group. As Tavener-Smith and De Vet (2006) put it, the perception that hip protectors reduce autonomy is, “a powerful deterrent to continued use in a population where independence is paramount”.

The positioning of hip protectors solely within a medical care context appears at odds with the practical reality of these products as items of clothing, worn within daily routines. The clothes we wear are loaded with meaning tied to our personal identity, sense of self, and how we ‘fit in’ with others. Designing a hip protector that meets a user’s psychological needs is rooted within the

subjective pursuit of understanding this meaning. If hip protectors are broadly perceived as garments it is understandable that they are subjected to the same visceral judgement we might apply when pondering the rails at a clothing retailer, i.e. how does it look and feel when I try it on? Is it 'me'? With this in mind, the broadly utilitarian aesthetic, lack of variation in colour and shape, and dominance of underwear style hip protectors, may all contribute to a dislike of current hip protector designs. This point is reinforced by Topo and Ilanen-Tahkavuori (2010) who examined how clothes provided by hospitals and other care institutions construct a notion of 'patienthood' as materialised ideology. Although the work looks more broadly at clothing worn by patients in care environments the principles discussed are easily applied to hip protectors. The authors argue that wearing patient clothing is a process of giving up control and identity. They reflect on the 'otherness' of patients' status that is underlined by the use of institutional clothing. They have developed a framework to distinguish between clothes that represent normality and clothes that represent otherness (see Table 2). This is very useful when viewed with respect to hip protector design, where characteristics, such as being in accordance with cultural norms of clothing, aesthetics, usability and comfort, all resonate with barriers to acceptance and adoption established in other literature.

Table 2. Features of patient clothing along the dimension of normality and otherness. Adapted from Topo and Ilanen-Tahkavuori (2010).

Normality, continuity ← Clothes...	Otherness, discontinuity Clothes... →
<ul style="list-style-type: none"> • are in accordance with gender specific cultural norms of clothing • protect one's privacy • conceal illness and disabilities • support or enable independence • have a familiar appearance and are aesthetically appealing • are easy to put on, pleasant to wear • fit the wearer 	<ul style="list-style-type: none"> • are not in accordance of cultural norms of clothing • are revealing and infantilising • highlight and stigmatise disabilities • prevent active involvement or action • have an "ugly" or odd appearance • are uncomfortable to put on and to wear • are the wrong size, do not fit the user appropriately
← Signals moral competence and situational control	Signals incompetence and inability, and loss of situational control →

4.2 Hip protector market and garment design

The review of online sales material reinforces the view of underwear hip protectors as garments by embracing the notion that 'fashion' is synonymous with youth. It seems deeply ironic that, for a product primarily designed for a broad ageing population, the vast majority of hip protectors are photographed on young, female bodies. Discourse concerning perceptions of body types, and the notion that hip protectors on 'attractive' bodies can increase sales, is beyond the scope of this paper. However, the way these products are marketed online brings into question who the intended purchasing audience is. For example, Mobility Smart, Medipost and Betterlife (part of the Lloyds

Pharmacy group) are three online retailers operating in the UK whose sales images of hip protectors are presented this way. They are typical of the type of hip protector suppliers found globally and provide a wide range of care-related products. Their target audience is wide, selling to individual consumers, but also to health care professionals and institutions. In this respect, choosing a hip protector may be out of the control of the individual who is expected to wear it, for example, purchased by a concerned relative or supplied by a care home. The loss of agency this represents could quite understandably lead to barriers to acceptance of hip protectors.

Underwear hip protectors dominate the market, including wrap around styles that are easier for carers to help frail people with limited mobility to put on and take off. However, hip protectors worn over clothing are also available, consisting of a belt which extends in width over the hips, with integrated soft or hard shell impact protection. There is little research into the preferences between hip protectors worn under or over clothing and further investigation into the prevalence of underwear style hip protectors is needed. Greater comfort, ease to put on and take off, less requirement for laundering, and less interference with incontinence products, seem like potential advantages to hip protectors worn over clothing. However, whilst investigating factors influencing hip protector use in community-dwelling older adults, Blalock et al. (2010) compared four different designs, three of which were underwear type products, but one was the HipGuard product worn over clothing. They found that factors relating to comfort and appearance were most disliked in the product worn over clothing compared to the underwear products. Perhaps the appearance of this type of product is susceptible to greater scrutiny as it is visible when worn. It may also be more uncomfortable if worn in bed, as was the expectation in this study. Further investigation is needed into attitudes towards hip protectors worn over clothing and the contexts where this style may be preferable to underwear products. This includes new hip protector designs with airbag technology integrated into a belt worn over clothing.

4.3 The cost of hip protectors

Hip protector products are expensive (retail prices range from about £22 to £99), especially compared to ordinary underwear, so it is surprising that cost is not reported more frequently as a barrier to initial acceptance. Many of the intervention studies reviewed (e.g. Bentzen et al., 2008a; Blalock et al., 2010; Cameron et al., 2011; Forsén et al., 2004) accessed funding to provide the hip protectors for free. In reporting rates of acceptance and adoption, the researchers do not also ask participants if they would continue using hip protectors if they had to pay for them themselves. In an American study, Burl et al. (2003) describe the cost of hip protectors as a “major barrier”, and recommend that health insurance providers cover the expense, arguing that would be more cost effective than covering treatment for hip fractures. Similarly, Honkanen et al. (2006) describe how nursing staff are discouraged by the cost of hip protectors with concerns that resources allocated towards them would be diverted from other important institutional programs. Over half of the participants interviewed (n=10) by Tavener-Smith and De Vet (2006) lived at home providing useful insight in attitudes towards hip protectors outside an institutional context. Costs were identified as a key concern to those living solely on their pension. An 83 year old Australian lady insisted that, “I can’t see the money in them. I can’t for the life of me... nearly \$A100 for two pairs of pants and two hip things”. In the UK, hip protectors are shown on the NHS supply chain website but the pressure on budgets well reported in the media limit their prescription to only the highest risk individuals.

The cost of the hip protectors studied by Laing et al. (2011) was investigated through suppliers online, ascertaining the lowest retail cost currently available. The authors only investigated the effects of pad geometry and material properties on the biomechanical effectiveness of 26

commercially available hip protectors they chose as a broad representation of the products available. There is no direct correlation between retail cost and hip protector efficacy, with examples of lower cost products having greater biomechanical effectiveness than higher cost ones. Of the examples reviewed, the visually slimmer hip protectors, with less bulky padding, offer lower levels of impact protection than other products with thicker pads. The less bulky appearance may make the products more visually appealing, but the perceived sophistication this brings also commands a higher retail price. For example, three of the slimmer hip protectors, Bort, LYDS and WonderHips, are priced between £50 and £70 per product, representing the more expensive end of the market.

5. Reflection

Hip fractures are a very serious condition in the elderly which can severely impact on quality of life and lead to an earlier death. Hip protectors are shown to be effective at reducing the risk of hip fractures, particularly in care home populations. Many barriers exist, relating to the design of hip protectors, preventing acceptance and long-term compliance. The lack of discourse on this topic within the design research community presents a unique opportunity for further research in this domain. Hip protectors are garments, but the academic interrogation of these products as designed fashion items is non-existent. Discourse concerning the design of hip protectors largely focuses on engineering and technical factors. However, a broader philosophical enquiry, underpinning a human centred design approach, and dealing with issues relating to semantics and identity is clearly long overdue.

The next step is to transition from the 'discover' to the 'define' phase of the double-diamond informing a design brief for new product development. This will include gathering the views of elderly participants through focus groups to understand what is perceived as acceptable, in terms of aesthetics and function, and expectations of product cost. The potential for co-design strategies with elderly people and healthcare professionals will also be investigated as part of this process. Statistically, women are at greater risk of hip fracture than men but analysis of attitudes and expectations towards hip protectors by gender is very limited. This will be an important part of further work examining the potential of hip protectors as lifestyle products rather than simply a medical intervention.

6. Conclusion

As the opportunities for human-centred design research are developed, this critical and contextual review underpins some key themes to explore with potential hip protector users. Protective clothing offers no protection if it is not worn, therefore receptivity is the key to eventual compliance. In order to foster long-term acceptance, design criteria including aesthetics, convenience, comfort and cost should be as important as the level of hip protection. Greater variety may be sought, responding to an adaptive design language based on identity and context, e.g. active ager or very elderly, masculine or feminine, colour, style, etc. Further motivation might be necessary to create long-term acceptance, such as hip protectors that enhance physique, improve proprioception, or have health monitoring capabilities. Finally, to promote earlier adoption within 'at risk' populations, could hip protectors be seen as a positive active ageing symbol, a self-statement of independence and healthy, active living?

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