

What Is Known About the Correlates and Impact of Excess Skin After Bariatric Surgery: a Scoping Review

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Abstract Although bariatric surgery (BS) improves health among adults with severe obesity, it results in excess skin in more than 70% of adults. The purpose of this study was to synthesize current knowledge on (1) the impact of excess skin experienced by adults after BS and (2) the correlates of excess

skin quantity and inconveniences. PubMed, PsyArticles, and CINAHL databases were searched in May 2016 for relevant studies. Titles, abstracts, and full texts of studies retrieved were screened independently by two reviewers against inclusion criteria: (1) peer-reviewed primary research studies, (2)

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samples with adults who underwent BS, and (3) studies reporting the impact of excess skin and/or excess skin correlates. Thirteen quantitative and eleven qualitative studies met inclusion criteria. Negative physical, psychosocial, and daily life impacts of excess skin were reported in 67, 75, and 83% of studies, respectively. Women reported more excess skin and greater inconveniences of excess skin than did men. Based on the quantitative studies, pre-BS BMI, time since BS, and type of BS were not significantly associated with inconveniences of excess skin; findings were inconclusive for other correlates found (e.g. age, weight loss, BMI). Excess skin may adversely impact adults' physical and psychosocial functioning, as well as their activities of daily life after BS. However, evidence is lacking to determine which adults may be at heightened risk of developing or being negatively impacted by excess skin. More research on correlates of excess skin is needed to inform the development of tailored interventions in those more vulnerable to developing excess skin after BS to mitigate adverse consequences.

Keywords Surplus skin · Bariatric surgery · Impacts

Introduction

The number of bariatric surgeries (BS) performed yearly has increased markedly in North America from 2003 to 2011 (+114%), reaching approximately 100,000 BSs yearly [1, 2]. Despite its benefits, BS is also associated with possible side effects (e.g. gastrointestinal disorders, vitamin deficiencies) [3]. Among the sometimes overlooked adverse consequences of massive weight loss associated with BS is excess skin in different regions of the body (e.g. abdomen, thighs, upper arms, chest) [4], which can lead to patients' dissatisfaction and may present physical and psychosocial challenges that can affect their health and ability to function. Given that at least 70% of adults report excess skin after BS [5–9], a growing number of researchers have investigated the impact of excess skin among adults post-BS. Using quantitative and qualitative methods, they have reported that subjects experienced physical (e.g. skin irritations, pain, infections), psychosocial (e.g. disgust, shame, anxiety), and daily living challenges (e.g. personal hygiene, getting dressed) [4–8]. As such, there is a real need to synthesize current knowledge on adults' experiences related to excess skin after BS to better understand the issues surrounding BS and inform healthcare providers about the extent to which excess skin adversely influences patients' recovery.

After BS, excess skin can only be removed surgically through plastic surgery [10, 11]. Researchers have shown that plastic surgery after BS can improve quality of life [10, 12, 13]. Between 60 and 80% of adults would like plastic surgery after massive weight loss [5, 14–17], but only a small

percentage of them (~10%) have access to such interventions [14, 18], and thus, a considerable proportion of adults must live with excess skin. Therefore, the identification of the sociodemographic, physical, psychosocial, and behavioural factors associated with excess skin and the inconveniences it creates is essential to inform the development of tailored interventions targeting at-risk adults to reduce negative impact of excess skin.

As interest in excess skin continues to grow within scientific and clinical communities, a synthesis of the range and nature of existing evidence on excess skin is important to help in the formulation of research projects and practical strategies. Scoping reviews provide a method to overview and analyse existing evidence on a specific topic to identify both what is already known and the gaps in existing research [19]. Therefore, a scoping review was undertaken to (1) identify the extent, range, and nature of quantitative and qualitative studies focused on the impact of excess skin experienced among adults after BS, (2) determine the correlates of the quantity of excess skin and inconveniences caused by excess skin, and 3) identify gaps in current knowledge.

Methods

Design

This scoping review was performed following the five steps outlined by Arksey and O'Malley [20] and enhanced by Levac et al. [21]: (1) identify the research question, (2) identify relevant studies, (3) select studies, (4) chart the data, and (5) collate, summarize, and report results. This method follows a narrative synthesis approach, which is well suited for reviewing studies that vary in methodological approaches [20]. This article does not contain any study with human participants or animals performed by any of the authors. Obtaining informed consent does not apply.

Eligibility Criteria

Studies, whether originating from quantitative or qualitative paradigms, were included in this review if they met the following criteria: (1) constituted primary research published in peer-reviewed journals, (2) focused on adults (≥ 18 years old) who had undergone BS, (3) reported the impact of excess skin experienced by patients or correlates of excess skin quantity or correlates of excess skin inconveniences, and (4) had full-text articles available in English or French. Reviews, editorials, commentaries, case reports, and studies that assessed the impact of plastic surgery without data on the impact of excess skin before plastic surgery were excluded.

Information Sources

The search strategy involved locating relevant studies in three databases: PubMed, PsyArticles, and CINAHL. This search was performed on May 5 (2016) without date restriction. An updated search was performed on June 15 (2017) to retrieve any studies published since the initial search, but no new study met the inclusion criteria. Additional studies were retrieved by manually searching the reference lists of all full-text articles retained after screening the articles found during the electronic search. Selected experts (AuB, MFL) were also consulted to see whether they had other studies to suggest.

Search and Study Selection

The search strategy was adapted for each database using its specific vocabulary map, employing keywords referring to excess skin (e.g. excess skin, surplus skin, skin fold, redundant skin) and MeSH terms that referred to BS. The restriction operators were “all adult”, “peer reviewed”, “English”, and “French”. The search strategy is shown in Table 1. All retrieved citations were imported into EndNote software (Version X7), and duplicate records were deleted. All remaining records were screened against inclusion and exclusion criteria independently by two reviewers (AnB and EB), first according to titles and abstracts, and then with the full-text papers of the selected abstracts. Disagreements were resolved by a third party (AuB). Reviewers’ agreement was calculated on a dichotomous scale (included versus excluded articles) using Cohen’s kappa coefficient and can be interpreted as

follows: 0–0.2 = none, 0.21–0.39 = minimal, 0.40–0.59 = weak, 0.6–0.79 = moderate, 0.8–0.9 = strong, >0.9 excellent agreement [22].

Selection and Categorization of Variables

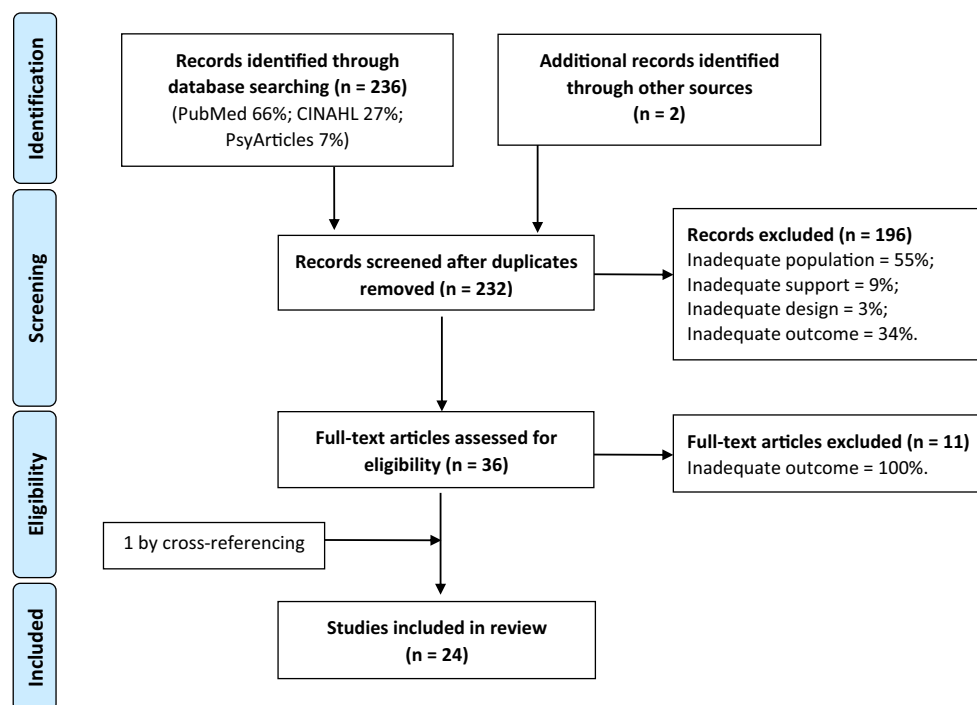
The following data from each study included in this review were coded and entered into a spreadsheet by one reviewer (EB) and verified by another (AnB): authors, publication year, country, study design, sample size, sample characteristics, type of BS, time elapsed since BS at recruitment, tools used to assess excess skin impacts, excess skin quantity, excess skin inconveniences, and excess skin correlates.

Data on the impact of excess skin experienced by participants were first extracted for each study and then classified into one of the main categories determined by AuB, namely psychosocial, physical, or daily life. Upon merging the different impacts, 18 subcategories were identified by AuB, EB, PB, and AJR (see Fig. 1). EB and AnB then re-read the results section of each study reviewed and categorized results into one of the 18 subcategories. Any disagreements regarding data interpretation were discussed by AuB, EB, AnB, PB, and AJR until consensus was achieved. When available in quantitative studies, the percentage of participants reporting an impact of excess skin was extracted for the 18 subcategories and categorized as either very prevalent ($\geq 70\%$), prevalent (51–69%), or less prevalent ($\leq 50\%$) to gauge the magnitude of the impact [23].

In addition, data on all correlates assessed were extracted from each study. For studies that reported a statistically

Table 1 Research equations for each database

Database	Equation
PubMed	(“Excess* skin”[All Fields] OR “skin excess”[All Fields] OR “surplus skin”[All Fields] OR “skin fold*”[All Fields] OR “redundant skin”[All Fields] OR “skin overhang*”[All Fields] OR “overhang* skin”[All Fields] OR “loose-overhanging skin”[All Fields] OR “lax* skin”[All Fields]) OR “skin lax*” [All Fields] OR “excess pendulous skin” [All Fields] OR “skin fold*” [All Fields] OR “sag* skin” [All Fields]) AND (“weight loss”[All Fields] OR “bariatric surgery”[All Fields]) AND (“humans”[MeSH Terms] AND English[lang] OR French[lang])
PsyArticles	(Any Field:(excess* skin) OR Any Field:(skin excess) OR Any Field:(surplus skin) OR Any Field:(skin fold*) OR Any Field:(redundant skin) OR Any Field:(skin overhang*) OR Any Field:(overhang* skin) OR Any Field:(loose overhanging skin) OR Any Field:(lax* skin) OR Any Field:(skin lax*) OR Any Field:(excess pendulous skin) OR Any Field:(skin fold*) OR Any Field:(sag* skin)) AND (Any Field:(weight loss) OR Any Field:(bariatric surgery)) AND Age Group: Adulthood (18 yrs. & older)
CINAHL	(Any Field:(excess* skin) OR Any Field:(skin excess) OR Any Field:(surplus skin) OR Any Field:(skin fold*) OR Any Field:(redundant skin) OR Any Field:(skin overhang*) OR Any Field:(overhang* skin) OR Any Field:(loose overhanging skin) OR Any Field:(lax* skin) OR Any Field:(skin lax*) OR Any Field:(excess pendulous skin) OR Any Field:(skin fold*) OR Any Field:(sag* skin)) AND (Any Field:(weight loss) OR Any Field:(bariatric surgery)) AND restriction operators: All Adult only; Human only; Language: English and French only.

Fig. 1 PRISMA flow diagram

significant association between correlates and quantity (self-reported or objectively measured) and/or inconveniences of excess skin, the direction of association was indicated with a “+” (for a positive association) or “−” (for a negative association). Non-significant associations reported were indicated with a “0”.

Results

Study Selection

The electronic search generated 236 references, of which six were duplicates. Two additional studies were identified by experts, for a total of 232 articles. After review of titles and abstracts, 196 were excluded because they did not meet all inclusion criteria. The full texts of the remaining 36 articles were assessed for eligibility and references were scanned, yielding one additional relevant study; of these, 24, representing 11 qualitative studies (46%) and 13 quantitative studies (54%), were included in the review (see Fig. 1). Agreement scores between reviewers (EB and AnB) were excellent for the screening of titles and abstracts ($k = 0.93$), and strong for screening of full texts ($k = 0.81$).

Study Characteristics

The reported characteristics of included studies are presented in Table 2. Most were cross-sectional ($n = 22$; 92%); two were prospective, with assessments of participants before and after

BS [35] and at 12 and 24 months following BS [34]. All were published between 2008 and 2016, with the vast majority ($n = 21$; 88%) published after 2011. Just under half (42%; $n = 10$) were conducted in Nordic countries, 33% ($n = 8$) in North America, and 25% ($n = 6$) in other countries.

Sample Characteristics

Table 2 presents the characteristics of participants included in the reviewed studies. In total, 2380 adults were included in the reviewed studies. Sample size ranged from 7 to 153 participants (mean = 32 ± 42) for qualitative studies, and from 26 to 485 (mean = 160 ± 135) for quantitative studies. Average age of participants across the studies was 45 ± 4 years, and the vast majority of participants were women, who made up at least 67% of the sample in all studies. Eleven studies did not provide additional sociodemographic data (46%) [6–8, 13, 28, 32, 34, 35, 37–39]. Five studies (21%) provided details on participants’ ethnic background, with at least 61% of their sample being Caucasian (range 61–100%) [4, 16, 24, 27, 31]. In the 10 (42%) studies that reported participants’ marital status, most were married (range 47–87%). Employment status was reported in six (21%) studies and ranged from 40 to 90% of the sample being employed. In five (21%) studies that considered education level, most participants had a high school or university diploma (range 48–100%). In general, participants were recruited 12 months or more after BS ([24] and [35] are exceptions), though there was a considerable range (i.e. 3 to 132 months). The type of BS most commonly performed was gastric bypass surgery (67%; $n = 16$); eight

Table 2 Study characteristics ($n = 24$)

Author	Country	Study design	Baseline sample size (n)	Women (%)	Mean age ($\pm$ SD) or range (years)	Time of recruitment	BS type
Qualitative studies ($n = 11$)							
Alegria et al. 2015 [24]	USA	IDI	11	100	23–65	3–51 m. after BS	AGB or GBS
Gilmartin 2013 [4]	UK	IDI	20	90	46 (29–63)	24–60 m. after BS	GBS
Groven et al. 2013 [25]	Norway	P	22	100	24–54	60–72 m. after BCS	NA
Heidmann et al. 2015 [26]	Denmark	QFG	12	70	25–74	72 m. after BS	GBS
Klassen et al. 2012 [27]	Canada and USA	IDI	43	93	47 $\pm$ 12	12–84 m. after BCS	NA
Lyons et al. 2014 [28]	Canada	GT	15	80	51 (32–65)	26 m. after BS	NA
Magdaleno et al. 2011 [29]	Brazil	I	7	100	40 $\pm$ 8	18–36 m. after BS	NA
Lier et al. 2016 [30]	Norway	IDI	10	70	45 $\pm$ 8	60 m. after BS	GBS
Poulsen et al. 2016 [31]	Canada and USA	DI	49	94	23–68	No more than 7 years after BCS	NA
Thorsby 2012 [32]	UK	E	153	67	NA	NA m. after BS	GBS
Zhou et al. 2015 [33]	Canada	GT	10	80	46 $\pm$ 10	12 m. or more after BCS	NA
Quantitative studies ($n = 13$)							
Aldaql et al. 2013 [7]	Saudia Arabia	CSS	64	80	36 $\pm$ 9	12 m. or more after BS	SG or GBS or AGB
Baillot et al. 2013 [9]	Canada	CSS	26	100	46 $\pm$ 2	12 m. or more after BS	GBS
Biörserud et al. 2011 [8]	Sweden	CSS	112	69	45 $\pm$ 12	28 $\pm$ 9 m. after BS	GBS
Biörserud et al. 2014 [34]	Sweden	PCS	57	74	20–50	Before BS (assessments 12 and/or 24 m. after surgery)	BPD/DS or GBS
Bioserud et al. 2016 [35]	Sweden	PCS	149	73	45 $\pm$ 12	Before BS (assessments before and 18 $\pm$ 1 m. after surgery)	GBS
Giordano et al. 2013 [6]	Finland	CSS	360	70	51 $\pm$ 11	At least 12 m. after BS (mean follow-up = 56.1 m.)	AGB, BPD/DS, SG or GBS
Kitzinger et al. 2012 [5]	Vienna	CSS	252	81	46 $\pm$ 12	24–96 m. after BS	GBS
Mitchell et al. 2008 [16]	USA	CSS	70	84	50 $\pm$ 9	72–120 m. after BS	GBS
Ramalho et al. 2015 [36]	Portugal	CSS	61	100	41 $\pm$ 9	19 $\pm$ 10 m. after BS	GBS, AGB or SG
Staalesen et al. 2013 [37]	Sweden	CSS	485	77	46 $\pm$ NA	24–132 m. after BS	NA
Staalesen et al. 2015 [13]	Sweden	CSS	94	85	21–68	Before and 12 m. after BCS	NA
Steffen et al. 2012 [38]	USA	CSS	160	86	47 $\pm$ 10	18–120 m. after BS	GBS
Wagenblast et al. 2014 [39]	Denmark	CSS	138	79	43	12 m. after BS	GBS

AGB adjustable gastric banding, BCS body contouring surgery, BPD/DS biliopancreatic deviation with duodenal switch, BS bariatric surgery, CSS cross-sectional study, DI descriptive and interpretative, E ethnographic, GBS gastric bypass surgery, GT grounded theory, I interviews, IDI in-depth interviews, m. months, NA not available, P phenomenological study, PCS prospective cohort study, QFG qualitative design with focus group, SG sleeve gastrectomy

studies (33%) did not report information on the type of BS performed.

Measures of Excess Skin Quantity

Excess skin quantity for different body parts and whole body were self-reported by participants using a 5-point scale from “none” to “very much” in six studies [6, 8, 13, 34, 35, 37]. Three studies [9, 13, 35] used objective methods to assess excess skin quantity [40–42]. In one study, excess skin was measured by trained personnel using a measuring tape, ruler, and plastic jars of different sizes in specific anatomic positions according to body parts [40]. In another, the anthropometric classification of body contour deformities after BS was used to assess grade of excess skin according to the size of the pannus in relation to fixed anatomic structures [41]. Finally, Staalesen et al. assessed excess skin objectively according to standardized clinical practice at their clinic using distance between anatomic landmarks [13].

Measures of Excess Skin Impact

Four self-reported questionnaires were used in the 13 quantitative studies to assess impact of excess skin. The English or Swedish versions of the reliable Sahlgrenska Excess Skin Questionnaire (SESQ) were administered in three studies [13, 35, 37]. The SESQ consists of 10 items that focus on symptoms caused by excess skin, which are rated on a 5-point Likert scale ranging from “never” to “all the time”. It also includes 10 open questions asking participants to describe problems caused by excess skin in relation to various body parts [43]. Five other investigations used a constructed questionnaire or a previous version of the current reliable SESQ [6, 8, 9, 34, 39]. No information on reliability and validity was provided for the next three questionnaires. The Post-Bariatric Satisfaction Questionnaire (PBSQ) [14] was used in two studies [5, 7]. The PBSQ includes 34 items that focus on the impact of excess skin, which are rated on a 3-point Likert scale ranging from “never” to “recurring”, as well as on cosmetic concerns and expectations regarding body contouring surgery. The Post-Bariatric Surgery Appearance (PBSA) [16], which focuses on cosmetic and body contouring concerns following BS, was used in two studies [16, 38]. The PBSA also asks participants to report on the presence or absence of sores, rashes, or skin breakdown caused by excess skin. The Excessive Skin Impairment Questionnaire (ESIQ) was used in one study [36]. It includes six items that assess impairment due to excess skin in six areas of life (i.e., personal satisfaction, work, relationships, romantic relationships, sexual life, hygiene), which are rated on a 4-point Likert scale ranging from “no disruption” to “extreme disruption”.

As detailed in Table 2, seven different data collection methods were used to obtain data on participants’ experiences

of excess skin in qualitative studies. Eight studies conducted interviews with participants [4, 24, 25, 27, 29–31, 33], whereas two conducted focus groups [26, 28] and one used observation [32]. The underlying approaches differed also significantly, with seven using a qualitative design [4, 24, 26, 27, 29–31], two using grounded theory approach [28, 33], one using a phenomenological approach [25], and one using an ethnographic approach [32].

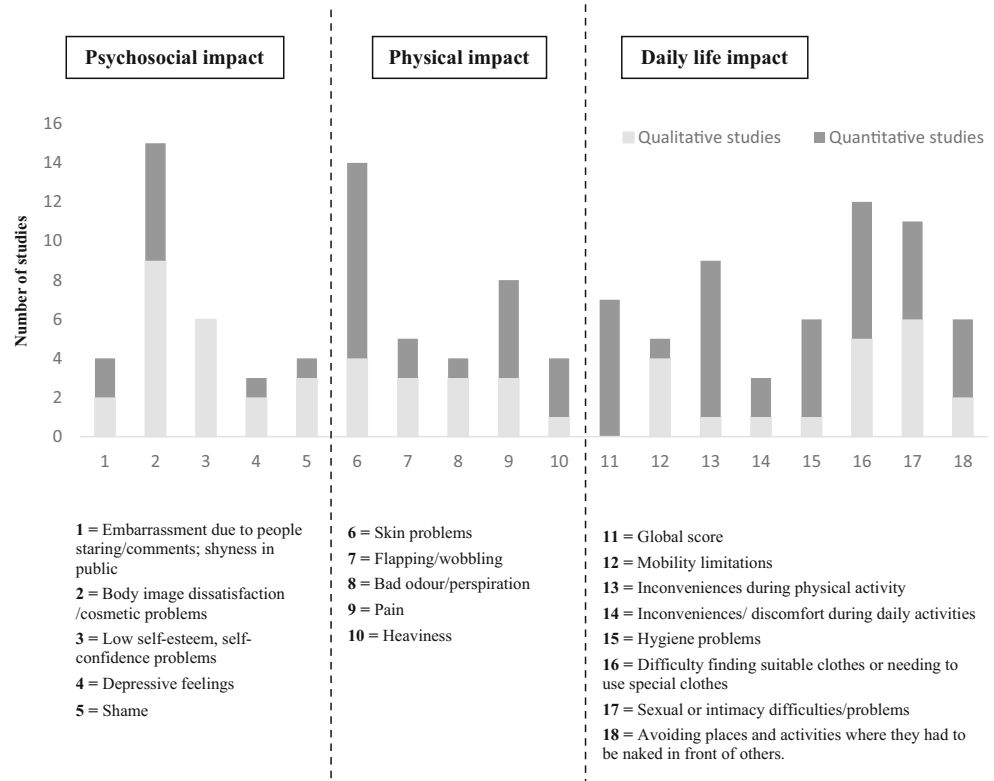
Measures of Inconveniences of Excess Skin

Excess skin inconveniences were measured in 12 quantitative studies using a 100-mm VAS ($n = 4$; 33%), the SESQ ($n = 3$; 25%), PBSA ($n = 2$; 17%), PBSQ ($n = 2$; 17%), and ESIQ ($n = 1$; 8%). In the SESQ, 10 items asked participants to rate the extent to which they were bothered by excess skin overall (i.e., for the body) and in specific body parts, using a 10-mm visual analogue scale (VAS) ranging from “no problem” to “worst possible problem” [13, 35, 37]. In the PBSA, participants were asked to indicate their current degree of (dis)satisfaction with excess skin in relation to various body parts on a 7-point Likert scale ranging from “very dissatisfied” to “very satisfied” [16, 38]. In the PBSQ, participants’ (dis)satisfaction with their appearance was assessed; however, these data are not included in this review because the question was not specific to excess skin [5, 7]. Overall impairment due to excess skin in the ESIQ was computed as the direct sum of impairment in the six areas of life [36]. For the remaining four studies (33%), excess skin inconveniences were reported by participants on a 100-mm VAS ranging from “no inconvenience at all” to “the worst conceivable inconvenience” [6, 8, 9, 34].

Results on the Impact of Excess Skin

The numbers of qualitative and quantitative studies reporting data on excess skin impact experienced by patients are presented in Fig. 2. Psychosocial impact of excess skin emerged in 100% of qualitative studies ($n = 11$) and 54% ($n = 7$) of quantitative studies. In particular, participants with excess skin experienced embarrassment due to people staring, shyness in public, body image dissatisfaction, self-esteem problems, feelings of depression, and shame. Data concerning physical impact of excess skin were reported in 55% ($n = 6$) of qualitative studies and in 77% ($n = 10$) of quantitative studies. Physical issues reported by participants included skin problems (e.g. dermatitis, intertriginous problems, rashes, irritations, eczema, fungal infections, itching), flapping/wobbling, bad odour, perspiration, pain, and skin heaviness. Finally, 82% of qualitative ($n = 9$) and 85% of quantitative studies ($n = 11$) provided data to suggest that excess skin has an impact on participants’ activities of daily living by limiting their mobility, causing inconveniences during physical activity, creating hygiene

Fig. 2 Number of qualitative and quantitative studies reporting psychosocial, physical, and daily life impact of excess skin



problems, making it difficult to find suitable clothes and/or necessary to find special clothes to hide or support excess skin, and making sexual or intimate relations difficult.

As shown in Table 3, studies varied considerably in terms of which types of impact they assessed (i.e., psychosocial, physical, daily life), and there was no evidence trend as to whether psychosocial, physical, or daily life function was most affected by excess skin because the studies were divided into different categories of prevalence (very prevalent, moderate, and low) for each subcategory.

Correlates of Excess Skin Quantity and Inconveniences

Of the 13 quantitative studies reviewed, nine provided data on associations between correlates and excess skin (69%). These are presented in Table 4. All nine reported data on associations between correlates and excess skin inconveniences (100%), whereas fewer reported on associations between correlates and self-reported excess skin quantity ($n = 7$; 78%) and objectively measured excess skin quantity ($n = 3$; 33%). Most statistical associations reported were with excess skin inconveniences ($n = 40$), with equal amounts for objectively measured excess skin quantity ($n = 12$) and self-reported excess skin quantity ($n = 11$). The correlates examined included anthropometric (i.e. pre-BS BMI, pre-BS circumference, pre-BS excess skin, current BMI, change in circumference, change in weight or BMI, breast volume), psychosocial (i.e. depressive symptoms, sexuality, body image, self-esteem),

sociodemographic (i.e. age, sex, pregnancy), surgery-related (i.e. time since BS, type of BS), and behavioural variables (i.e. physical activity level). In addition, five studies reported on the associations between self-reported excess skin quantity, objectively measured excess skin quantity, and excess skin inconveniences.

Sex, age, and change in weight or BMI were most frequently studied ($n = 6$ for each; 67%). Regarding sex, findings showed that women reported more excess skin quantity and inconveniences compared to men [6, 8, 34, 35, 37]. Neither pre-surgery BMI, time since surgery, nor type of BS was significantly associated with excess skin inconveniences [6, 8, 9, 34, 36, 38]. Self-reported and objectively measured excess skin quantity was positively associated with excess skin inconveniences [13, 34, 35, 37]. The findings were either inconsistent or fewer than three studies reported results for all other associations. Also, only one study, due to its prospective design, presented associations between baseline and follow-up changes (18 months after BS) (Δ); it found significant correlations between Δ BMI and Δ excess skin only for abdominal excess skin and not for other excess skin localizations ($r_s = 0.26$; $p = 0.004$) [35] (data not shown in Table 4).

Discussion

To our knowledge, this scoping review is the first to compile knowledge on the impact of excess skin and correlates of

Table 3 Impacts of excess skin and their prevalence

Impacts of excess skin		References		Percentage of participants with impacts		
Subcategories		Qualitative studies	Quantitative studies	+++ (≥70%)	++ (50– 69.9%)	+ (<50%)
Psychosocial	Embarrassment due to people staring/comments; shyness in public	(4, 29)	(8, 9)			
	Body image dissatisfaction/cosmetic problems: feeling ugly/unattractive/disgusting/old	(4, 27, 31–33, 39, 41–43)	(8, 13, 25, 26, 30, 38)	(13, 26)		(8)
	Self-esteem, self-confidence problem	(4, 27, 31, 33, 42, 43)				
	Depressive feelings	(4, 27)	(38)			
	Shame	(4, 40, 42)	(8)			
Physical	Skin problem (dermatitis, intertriginous problems, rashes, irritations, eczema, fungal infections, itching)	(32, 33, 41, 42)	(5, 7–9, 13, 16, 24–26, 30)	(5, 13)	(26)	(7, 8, 16)
	Flapping/wobbling	(4, 29, 42)	(9, 25)			
	Bad odour/perspiration	(32, 33, 42)	(8)			(8)
	Pain	(33, 41, 42)	(8, 9, 13, 26, 30)			
	Heaviness	(33)	(8, 9, 25)			
Daily life	Daily life inconveniences/discomfort/problems (global score)		(6, 8, 9, 13, 24, 25, 38)	(6, 9, 13, 38)		
	Mobility limitations	(32, 33, 41, 43)	(9)			
	Inconveniences/discomfort during physical activity	(33)	(5, 7–9, 13, 24–26)	(5, 9, 13)	(26)	(7, 8)
	Inconveniences/discomfort during daily activities	(4)	(13, 26)			
	Hygiene problems	(41)	(8, 9, 13, 26, 38)	(13)		(8, 26, 38)
	Difficulty finding clothes or needing to use special clothes	(27, 29, 32, 33, 39, 42)	(5, 7, 8, 13, 25, 26, 30)	(5, 13, 26)		(7, 8)
	Sexual or intimacy difficulties/problems	(4, 27, 33, 39, 41, 42)	(13, 24, 26, 30, 38)	(13)	(26, 30)	(38)
	Avoiding places and activities where they had to be naked in front of others.	(4, 27)	(8, 9, 25, 30)		(8)	

excess skin following BS. It provides important insight into the current state of evidence and helps to identify gaps that need to be addressed to move research and practice forward.

Although massive weight loss after BS is linked to several improvements in patients' physical and mental health, as well as various aspects of their quality of life [44–47], this review shows that BS can have negative impacts in both the psychological (e.g. body image dissatisfaction, poor self-esteem) and physical (e.g. flapping, irritation) domains, as well as in daily (e.g. clothing restrictions) and personal life (e.g. sexual or intimacy difficulties). After BS, many adults must live with excess skin. This review of qualitative and quantitative studies suggests that excess skin could attenuate the benefits of massive weight loss and restrain quality of life improvements post-BS [44]. The prevalence of participants experiencing impaired psychosocial, physical, and daily life functioning varied greatly in the different quantitative studies included. Thus, no conclusion can be drawn regarding the magnitude of the impact of excess skin post-BS. These inconsistencies may be

due to selection bias or heterogeneous measures used in the investigations. Another explanation may be that excess skin consequences fluctuate at inter- and intra-personal levels during the months following BS.

The analysis of the existing literature showed that more studies looked at excess skin inconveniences than at excess skin quantity, and the number of associations reported by the reviewed studies was greater for the former. Whereas the studies examined concluded that women report more excess skin-related inconveniences compared to men [6, 8, 34, 35, 37], this review shows that most studies still focus on women. Thus, more attention should be focused on men in the future. In addition, pre-surgery BMI, time since surgery, and type of surgery were not associated with excess skin inconveniences [6, 8, 9, 34, 36], and no trends were observed for other outcomes (e.g. pre-BS body circumference, pre-BS excess skin, current BMI, change in circumference, change in weight or BMI, breast volume, depressive symptoms, sexuality, body image, self-esteem, age, pregnancy, physical activity level) due to contradictory

Table 4 Association of excess skin inconveniences, self-declared excess skin quantity, and objectively measured excess skin quantity and various outcomes ($n = 9$ studies)

	Association with ES inconveniences			Association with self-declared ES quantity			Association with objectively measured ES quantity		
	+	–	0	+	–	0	+	–	0
Female	(8, 24–26); (6)*		(28)*	(6, 8, 25, 26)					
Age	(9)	(8)	(38); (6)* (28)*			(26)			(9)
Pregnancy									(24) Ab
Pre-surgery BMI			(8, 9)				(24)* B; A		(9)
Pre-surgery excess skin							(24)* Ab; A; T		
Actual BMI	(8, 28)*		(9); (6)*						(9)
Pre-surgery body circumference							(24)9* A; T		
Circumference change		(25)			(25)				
Weight loss or BMI change	(8, 25); (6)*		(9, 28, 38)*	(25)					(9)
Breast volume							(24)* B		
Time since surgery			(6, 8, 9, 28, 38)*						[9]
Type of surgery			(6, 25)	(25)					
Physical activity rate			(8)						
Depressive symptoms				(38) Ab**					
Female Sexual Function Index			(38)						
Self-esteem		(9)							
Body image concerns	(38)*								
Self-declared excess skin quantity	(25, 26)						(24)		(13)
Objectively measured excess skin quantity	(3, 24)		(9)	(24)		(13)			

+ = significant positive association; – = significant negative association; 0 = no significant association; * = multivariate model; ** = women with excess skin on the abdomen presented with more depressive symptoms than women without excess skin; A = arm; Ab = abdominal; B = breast; BMI = body mass index; T = thigh

results or the limited number of studies. The same can be said for all associations tested with objectively measured quantity of excess skin and self-reported quantity of excess skin. Thus, according to our findings, there is a lack of data on associations with excess skin, and especially associations with excess skin quantity, probably because objectively measured quantity of excess skin is more difficult to assess. Yet patients and health professionals are particularly interested in knowing what factors could predict excess skin quantity following BS, such as age, ethnicity, magnitude of weight loss, skin quality, or specific behaviours (smoking, diet, inactivity).

In general, assessment of correlates was limited to a few sociodemographic, surgical, behavioural, and psychological variables. Sex, age, and weight loss or BMI change were the most studied correlates, probably because these data were easy to obtain. Although these results are interesting, they do not explain the processes by which the same quantity of excess skin is experienced differently from one individual to another. In this respect, the psychosocial aspects warrant further study, and body dissatisfaction could be particularly relevant, given its relation with body appearance, a key dimension for individuals having undergone a significant body change

following BS. None of the studies reviewed had specifically examined the relationship between excess skin inconvenience, excess skin quantity measured objectively, and excess skin quantity reported by participants. Yet these variables are important for determining which of the two types of evaluation of excess skin (objective or subjective) is most strongly associated with inconveniences. Integrating these variables would also be useful to study whether a distortion of body image (difference between self-reported and objectively measured excess skin quantity) is related to inconveniences caused by excess skin. We also noted that few studies in our review had performed multivariate analyses, thereby limiting any conclusions about associations.

Thus, this scoping review shows there is still an information gap regarding who is more likely to have higher excess skin quantity and to report more excess skin inconveniences. Studies on correlates of excess skin quantity and inconveniences are also lacking. More data are needed to better inform patients before BS and to better characterize, understand, and manage patients.

The 24 studies reviewed included 2380 adults and used quantitative or qualitative designs. However, although the

development of excess skin and of inconveniences caused by excess skin is a dynamic process, longitudinal investigations with multiple time measures are missing. Currently, we have no evidence to ascertain whether excess skin and the inconveniences caused by excess skin increase progressively until reaching a nadir, and whether they evolve in parallel. Such information could be valuable to professionals for informing and helping patients anticipate post-BS changes so that appropriate interventions (psychosocial or plastic surgery) can be proposed at the right time.

A quasi-absence of studies with objective measures of excess skin quantity was observed in this review; also, none of the studies reviewed used mixed approaches, whereas having complementary quantitative and qualitative data could be useful for addressing the complexity of the problem.

This review highlights the need for well-designed multicentre prospective studies with repeated measures to describe the evolution of excess skin and its impacts, as well as to identify more correlates and determinants of excess skin quantity and inconveniences. Sociocultural (e.g. social support, marital satisfaction, media, norms, socioeconomic status), psychosocial (e.g. psychosocial anxiety, body dissatisfaction, depression), and behavioural variables (e.g. physical activity level, smoking) should be studied in greater depth to better understand the elements likely to influence the development of excess skin and excess skin inconveniences experienced by patients following BS. Moreover, systematic coupling of objective and self-reported measures of excess skin quantity would be useful in studies to distinguish their respective predictors and possible differential associations with inconveniences. Improving the current evidence-based knowledge will require better measures of excess skin impact and objective measures of excess skin quantity; at a minimum, the reliable tools developed by Biorserud et al. [40, 43] should be used in future investigations. However, future psychometric studies should be developed to conceptually clarify excess skin inconveniences and refine available questionnaires.

In view of the negative psychological, physical, and daily life impacts of excess skin post-BS, more detailed information should be provided to BS candidates about the potential impacts of excess skin on their daily life. Also, during post-BS follow-up, excess skin quantity and inconveniences should be regularly monitored and discussed with the bariatric surgery team and/or plastic surgeon to provide adequate support to patients in need. The recent emergence of this research field explains why there is, as yet, no evidence regarding the best means to manage patients in this situation.

In conclusion, further research is needed, with objective and subjective measures of excess skin quantity, to improve our understanding of the development of excess skin and its inconveniences. More studies are needed to understand the moderators and determinants of excess skin quantity and inconveniences, in order to improve healthcare services

provided to patients before and after BS and to offer interventions targeting modifiable factors. We strongly believe such research will provide evidence of the need to provide additional follow-up to patients. Indeed, to stop the obesity epidemic, it is not enough to intervene in such a way as to produce weight loss; we also need to ensure that people who undergo weight reduction can fully benefit from their weight loss (improved quality of life) and that their psychological and social well-being (avoidance of discomfort, improved interpersonal relations, reduced stigma) is enhanced or at least preserved.

Compliance with Ethical Standards

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