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The Musculoskeletal Consequences of Breast Reconstruction using the Latissimus Dorsi Muscle for Women following Mastectomy for Breast Cancer: A Critical Review

Abstract

Breast reconstruction using the Latissimus Dorsi (LD) flap following mastectomy is an important management option in breast cancer. However, one common, but often ignored, complication following LD flap is shoulder dysfunction. The aim of this critical review was to comprehensively assess the musculoskeletal impact of LD breast reconstruction and evaluate the functional outcome following surgery. Five electronic databases were searched including: Medline, Embase, CINAHL Plus (Cumulative Index to Nursing and Allied Health), PubMed and Web of Science. Databases were searched from 2006 – 2016, and only full text, English language articles were included. Twenty-two observational studies and two surveys were reviewed with sample sizes ranging from six to 206 participants. The majority of studies had small sample sizes and were retrospective in nature. Nevertheless, there is evidence to suggest that there is some degree of weakness and reduced mobility at the shoulder following LD muscle transfer. The literature demonstrates that there is considerable morbidity in the immediate postoperative period with functional recovery varying between studies. The majority of work tends to be limited and often gives conflicting results; therefore, further investigation is required in order to determine underlying factors that contribute to a reduction in function and activities of daily living.

Word Count: 200 words
Introduction

Breast cancer remains the most common cancer diagnosed in women worldwide (Cancer Research UK, 2014). Within the UK, breast cancer ranks as the third most common cause of cancer death, with a lifetime prevalence of one in every eight women (Cancer Research UK, 2014). Despite breast cancer being the most common cancer in women globally, mortality from the disease is decreasing; earlier detection and developments in treatment have led to an increase in survival rates (Winters et al. 2012; Ditsch et al. 2013; Thiruchelvam et al. 2013; Cho et al. 2014).

Significant progress continues to be made in treating the disease, with up to 78% of women expected to live 10 years or more after diagnosis (Cancer Research UK, 2014). The primary aim of breast cancer treatment is to reduce the risk of premature death by removing the tumour and administering any other adjuvant treatment necessary (Senkus et al. 2013). Surgery is usually the initial stage of treatment, either by lumpectomy or mastectomy, both of which can alter body image and significantly change breast aesthetics (Ciesla and Bak, 2012; Thiruchelvam et al. 2013).

Treatment for breast cancer often includes mastectomy, and breast reconstruction is considered an important management option (Rifaat et al. 2008; Spector et al. 2011; Ditsch et al. 2012). The UK National Institute for Health and Clinical Excellence (NICE) recommends that reconstruction should be available to all women with breast cancer at the initial surgery (Winters et al. 2012). There are many reconstructive methods available and the main techniques used for breast reconstruction include; implants, autologous tissue, or a combination of the two (Fodor et al. 2011; Thiruchelvam et al. 2013). Reconstruction surgery can be performed immediately or delayed, with procedures varying in surgical complexity, recovery time and associated complications (Spector et al. 2011; Fraser et al. 2013). The autologous reconstructions fall into two groups: those that use fat and skin (DIEP: Deep inferior epigastric perforator from the abdomen; SIEA: Superficial inferior epigastric artery from the abdomen; IGAP: Inferior gluteal artery perforator from buttock crease; SGAP: Superior gluteal artery perforator from the upper buttock), and those that also use muscle (LD: Latissimus Dorsi flap; TRAM: Transverse Rectus Abdominis myocutaneous flap from the abdomen, TUG: Transverse upper Gracilis muscle from the upper inner thigh).

There are a number of reasons why one particular reconstruction method is preferred over another. However, LD flap reconstruction is one of the most widely used surgical procedures for women with breast cancer undergoing breast reconstruction. Reconstruction using the LD muscle has been described in a variety of reconstructive
methods since 1906 (Hamdi et al. 2008). Following mastectomy, the LD is dissected along with a skin paddle and overlying fat (de Oliviera et al. 2010; Kim et al. 2013; Smith, 2014). Once elevated, it may be transposed anteriorly under the axilla into the breast pocket as a musculocutaneous flap (Losken et al. 2010; Smith, 2014). The LD is a large flat muscle and is therefore often further augmented with implants or fat grafting to provide adequate symmetry and cosmesis (Teymouri et al. 2006; Fraser et al. 2013; Smith, 2014). The LD is the largest muscle in the human body (Forthomme et al. 2010; Ciesla and Bak, 2012) and acts on the shoulder during adduction, medial rotation, extension and assists the scapula in depression (Spear and Hess, 2004; Forthomme et al. 2010; Giordano et al. 2011; Bhatt et al. 2013; Sowa et al. 2016). The LD is thus involved in shoulder motion and plays an important role in shoulder joint biomechanics; the removal or replacement of this versatile muscle would be expected to affect shoulder movement, however, the extent to which this occurs is unknown.

There appears to be a contradiction within the literature regarding the problems associated with LD reconstructive surgery. While the procedure has demonstrated positive surgical outcomes, with apparent minimal donor-site morbidity (Teymouri et al. 2006; Reefy et al. 2010; Giordano et al. 2011; Perdikis et al. 2011; Kim et al. 2012; Tomita et al. 2013), some commonly reported complications associated with this flap include: seroma formation, wound infection, flap necrosis and shoulder dysfunction (Sajid et al. 2011; Szychta et al. 2013). LD breast reconstruction has traditionally been viewed as an effective method of autologous breast reconstruction, with shoulder impairment reportedly being minimal and having insignificant functional consequences (Saint-Cyr et al. 2009; Brackley et al. 2010). However, recent studies have shown that objective measurements of shoulder range, power, strength and endurance have decreased following the loss of the LD (Clough et al. 2002; Glassey et al. 2008; Giordani et al. 2011; Lutringer et al. 2012). Previous literature exploring the effectiveness of LD reconstruction has mainly focused on body image, aesthetic results and wound healing (Chow et al. 2008; De Gourney et al. 2010) with little in-depth investigation of the impact of this surgery on shoulder function. Recent information emerging from the literature would suggest that shoulder function is significantly impaired years after surgery (Giordano et al. 2011) and that breast reconstruction using LD flap is not as benign as previously thought and may result in significant musculoskeletal dysfunction (Lutringer et al. 2012).

Perhaps the most detailed analysis of the impact of mastectomy and breast reconstruction on women with breast cancer was the National Mastectomy and Breast Reconstruction Audit (NMBRA, 2011). This large audit captured the experiences of women, who had mastectomy or breast reconstruction, between January 2008 and March 2009. The audit was conducted across 150 NHS acute trusts in England, 114 independent sector hospitals and six NHS
trusts in Wales and Scotland, and reported women’s experience of care at three months and the impact of mastectomy or breast reconstruction on quality of life (QoL) at 18 months postoperatively. Of those sent questionnaires (n=10,521), 82% (n=8,636) consented to participate, and of these 3,389 had immediate and 1,731 delayed breast reconstruction. The NMBRA identified those who had breast reconstruction using LD flap and explored the impact of this procedure; the audit was summarised in a recent report by Jeevan et al. (2014). When questioned on their experience of functional impairment at 18 months postoperatively, approximately 20-25% of women who had immediate or delayed LD reconstruction reported that they had experienced difficulties, ‘most or all of the time’, with activities of daily living, such as lifting or carrying heavy objects (e.g. groceries), reaching for objects or doing repeated activities with shoulder or back muscles. For women who were unable to do simple activities of daily living, most or all of the time, the impact on QoL is likely to be significant. Unfortunately, the NMBRA is limited in its reporting of the extent and impact of the musculoskeletal consequences of breast reconstruction. In terms of describing the musculoskeletal consequences of breast reconstruction the NMBRA did not give any indication of the extent of any physical impairment for the 75 - 80% of women who have reconstruction but are not affected ‘most or all of the time’ by their surgery. In terms of the impact of the reconstruction on the QoL of women, the NMBRA had only limited detail. For example there was little discussion on limitations to participation for women postoperatively (e.g. return to work), nor was there any exploration of the barriers to movement or function such as pain beliefs or fear avoidance beliefs for women who have had reconstructive surgery. However, it was not the aim of the NMBRA to comprehensively explore the musculoskeletal consequences of breast reconstruction.

A number of critical reviews have been carried out investigating the functional impact of LD breast reconstruction (Spear and Hess, 2005; Smith, 2014), and perhaps the most comprehensive of these is a systematic review by Lee and Mun (2014) examining functional donor-site morbidity following LD muscle transfer. These authors concluded that LD muscle donor sites may not be as resistant to transfer for reconstruction as previously considered and that a better understanding of functional donor site morbidity following LD muscle transfer would allow surgeons to inform patients regarding donor-site expectations and to accomplish better surgical outcomes. In comparison to this current review, Lee and Mun (2014) applied restrictions on the type of literature reviewed. Therefore, in order to provide a comprehensive assessment of the musculoskeletal impact of LD breast reconstruction and evaluate the functional outcome of surgery, all relevant literature published within the last 10 years was included in this critical review.
Methods

One of the primary aims of a systematic review is to answer a specific research question (Liberati et al. 2009), in contrast, this critical review set out to comprehensively assess the musculoskeletal impact of LD breast reconstruction and evaluate the functional outcome following surgery. As such, this review had to be much broader than a traditional, very focused, systematic review. Additionally, in order to present a comprehensive overview of the literature in the field this review presents the findings from a broad range of research methodologies rather than only randomised controlled trials, which would normally be the focus of traditional systematic reviews (Liberati et al. 2009). Nevertheless, in order to identify appropriate literature, a detailed and structured systematic search strategy was developed with the advice of our faculty librarian, an information specialist. Five electronic databases were searched, to identify potential research for inclusion in the review. Databases searched were Medline, Embase, CINAHL Plus (Cumulative Index to Nursing and Allied Health), PubMed and Web of Science, and the keywords included; mammoplasty, breast reconstruction, breast surgery, LD, LDMF, Latissimus Dorsi, musculoskeletal, function, effect, outcome, impact, consequence and complication. Databases were searched from 2006 - 2016. Only those articles with study populations of women who had undergone LD breast reconstruction following mastectomy for breast cancer were included. There was no restriction put on the type of studies included in this review due to the dearth of literature in this area. Only full text, English language articles were included in the review. Titles and abstracts of identified papers were initially reviewed with full article reviews performed on those presenting specific data regarding the musculoskeletal impact of surgery; 24 articles were finally included. A total of 22 observational studies and two surveys were reviewed with sample sizes ranging from six to 206 participants.

Results

A number of authors have used the Disability of the Arm, Shoulder and Hand Questionnaire (DASH), to evaluate shoulder function following LD flap breast reconstruction with study design and follow-up varying from study to study (Glassey et al. 2008; Koh and Morrison, 2009; Saint-Cyr et al. 2009; Brackley et al. 2010; Button et al. 2010; Bonomi et al. 2012; Paolini et al. 2014; Yang et al. 2015; Garusi et al. 2016; van Huizum et al.2016). The DASH questionnaire consists of 30 items relating to activities of daily living, work, sport and music, each question of which has five options for response. This questionnaire provides a percentage disability score, where 0 equates to no disability and 100 to complete disability.
Glassey et al. (2008) assessed shoulder morbidity and recovery time scales in patients (n=22) undergoing LD breast reconstruction. Assessments were carried out preoperatively and then at six weeks, six months, and one year postoperatively. Shoulder range of movement (ROM), strength, function, and pain were assessed prospectively, using standardised objective assessments, including DASH. The results demonstrated that strength, disability scores, neural glide, and discomfort were abnormal at six months, however, results revealed no significant loss of ROM, strength, function, or pain at one year. DASH results demonstrated an initial deterioration in function at both six weeks (mean DASH 14.4) and six months (mean DASH 10) following surgery, however, no statistical analysis of the results was carried out due to the small sample size. At the one year postoperative follow up (mean DASH 7.7), the disability score had neared the preoperative value attained (mean DASH 7.4), but had failed to return to baseline. A larger study conducted by Button et al. (2010) prospectively assessed shoulder morbidity in patients (n=58) following LD breast reconstruction; preoperatively and at eight postoperative time points (first clinic visit, six weeks, three, six, 12, 18, 24 and 36 months). DASH scores were both clinically and statistically significantly elevated from the preoperative mean at the first postoperative visit (mean DASH 49) and also at six weeks (mean DASH 29) and three months following surgery (mean DASH 19). Although they found a functionally insignificant increase in long-term disability scores, a small subset of patients do develop long-term impairment following surgery. Interestingly, a strong, significant correlation was found between three month DASH score and long term function (p < 0.0003); patients with DASH>20 fare significantly worse in the long-term (mean 20 point increase, p < 0.001). In the same study, authors indicated an association between physiotherapy and positive functional outcomes.

More recently, a study conducted by Garusi et al. (2016) evaluated shoulder function in patients (n=86) following LD breast reconstruction. Shoulder ROM was assessed by a physiotherapist, and patients also completed the DASH questionnaire. For the majority of patients, the results from the physiotherapy assessment demonstrated a shoulder joint recovery exceeding 80% in all movements at least one year following surgery. Regarding DASH, almost two thirds of patients scored ≤20, indicating minimal disability among the group. Interestingly, Garusi et al. (2016) found that DASH scores decreased in those who participated in sports and particularly those sports involving the LD muscle (DASH score of 10.8 and 7.5 respectively). The findings from this study would suggest that LD muscle transfer results in minimal disability among this group. However, due to the retrospective nature of this study and considering that the contralateral LD was used as a control, these findings cannot be used as an indication of shoulder joint recovery as they do not compare preoperative and postoperative results.
A study conducted by Van Huizum et al. (2016) assessed the long-term effect of LD breast reconstruction on the strength profile of the upper extremity, comparing patients (n=12) and matched controls (n=20). Isometric strength was measured in a number of arm orientations and in different torque directions in order to determine the strength profiles of each participant. The results from the assessment revealed a statistically significant loss of synergistic LD torque strength, a mean of 3.5 years following the muscle transfer. The mean total DASH score among patients was 16.5, which was significantly higher than the mean of 2.7 scored among the controls (p=0.001). Among the patients, no relationship was found between total DASH score and time since surgery. However, the loss of strength among patients correlated significantly with a higher DASH score. These findings need to be interpreted with care as although the DASH score among patients was significantly higher than that of controls, the mean DASH is still indicative of minimal disability among the group. In addition, one of limitations reported by the authors is that controls were selected on the basis that they had no upper limb dysfunction. Therefore, these scores may not be representative of the general population and this may have impacted the results.

Yang et al. (2015) prospectively evaluated arm and shoulder function and QoL in patients (n=31) following breast reconstruction with LD flap. The manual muscle test and ROM of the affected upper extremity were carried out prior to surgery and then at five postoperative time-points (two weeks, six weeks, three months, six months and 12 months). DASH was used to assess functional disability, and QoL was assessed using the 36-item Short Form Health Survey (SF-36). These assessments were carried out before the surgery and then at three postoperative time points (three, six and 12 months). As with manual muscle test scores, all ROM scores significantly decreased at the two week postoperative assessment compared to the preoperative scores. The range of flexion (p<0.001), abduction (p=0.001), and external rotation (p=0.002) were significantly decreased at six weeks postoperatively, as were flexion (p<0.001) and abduction (p=0.004) at the three month assessment. Postoperative functional disability scores (as per the DASH) were significantly elevated at the three, six and 12 month follow-up. The physical component of the SF-36 decreased significantly until the six month postoperative time point and remained below baseline one year following surgery. These results are in accordance with other studies which demonstrate that in the immediate postoperative period significant deficits are expected, however disability scores can begin to return to baseline 12 months following surgery (Glassey et al. 2008), yet some fail to reach preoperative values, even up to three years following surgery (Button et al. 2010).

In 2009, Koh and Morrison used the DASH to retrospectively evaluate the functional outcome of surgery following LD reconstruction in a diverse group of patients (n=25), including those undergoing breast
reconstruction (n=6). Authors assessed the functional impairment following LD myocutaneous flap with a follow up period ranging from three to 52 months. Results highlighted the reduced ROM that was associated with the removal of the LD, and in particular how this deficit may significantly contribute to the patient’s involvement in physical activity, especially those who were active and participated in sporting activities. Results revealed that one third of patients reported scores of 30 or more on the DASH, which corresponded to a mild to moderate functional deficit. Among the six patients who had breast reconstruction, four underwent bilateral LD flap surgery. Within this sub-group, only one patient had a significant DASH score of 31. However, all four patients experienced moderate to severe impairment with sports and/or gardening activities and all three patients with significant sporting impairment and three of five patients with significant impaired gardening belong to this subgroup. These results, albeit from a very small sample, demonstrate the potential significant limitations that can incur following the removal of the LD. Moreover, a study conducted by Paolini et al. (2014) measured the functional implications following bilateral mastectomy and immediate LD flap breast reconstruction also using DASH. Patients (n=30) were assessed between 12-51 months after surgery, and among those, 80% presented a mild dysfunctional deficit, while the remaining 20% demonstrated a moderate one. Results showed that the onset of major complications requiring early secondary surgery were statistically associated with higher DASH scores, and arm and shoulder pain (p<0.05). These findings would imply that a functional impairment is present following surgery, however, once again due to the small sample sizes and inconsistent follow up, the extent of this cannot be determined.

Saint-Cyr et al. (2009) carried out a study assessing patients (n=20) who underwent breast reconstruction with a pedicled muscle-sparing LD flap. Functional evaluation was conducted at least three months postoperatively using DASH, and in addition, a postoperative ROM analysis and instrumented strength test comparing the operated and non-operated sides were carried out. The results found no statistically significant loss of ROM, strength, function or pain with two patients reporting minor functional impact. DASH revealed low disability scores for the mean functional, sport and work components. A similar study conducted by Brackley et al. (2010) retrospectively assessed shoulder morbidity in patients (n=18) following breast reconstruction using the muscle sparing LD flap. DASH was used to objectively assess shoulder morbidity at least six months following surgery. Normal scores were obtained regarding activities of daily living (ADL) (mean DASH 6.42), with a slight increase in scoring for higher performance activities such as work (mean DASH 7.75) and sport (mean DASH 15.43). Despite the modality assessed, i.e. work, sport and playing musical instruments, all scores demonstrated no difficulty in function of the shoulder. These results demonstrate that by utilising the muscle sparing method of reconstruction
whereby only a small strip of muscle is sacrificed, leaving the remaining muscle intact can result in minimal functional sequelae in contrast to often opposing results demonstrated in patients following complete LD muscle transfer.

Conflicting results were presented by Bonomi et al. (2012) who retrospectively analysed three different types of LD flaps using DASH, four to seven months following breast reconstruction. Patients (n=82) were divided into three groups; patients who underwent standard LD flap with implant (n=35), a muscle sparing LD flap with implant (n=18) and autologous LD reconstruction (n=29). A postoperative physical examination was also carried out comparing the operated and non-operated sides, and evaluation consisted of an active ROM assessment of the shoulder and muscle strength tests conducted six months following surgery. Results found that although decreased shoulder function was noted, 93% of patients perceived no permanent functional impairment of the shoulder postoperatively. The mean DASH scores revealed that patients had no difficulty with ADL (mean DASH 7.8), work status (mean DASH 11.3) or sports (mean DASH 19). In addition, the patient’s ability to perform sport-related activities was unchanged in 88% of patients. Patients perceived no limitation in muscle strength or ROM between the operated or non-operated sides. Based on the physiotherapist assessment, there was a reduction of ≤10° in flexion, extension, and external rotation between the operated and non-operated shoulders in a small subset of patients (n=13). Authors concluded that sacrificing the LD has minimal functional impact and that most patients have few complaints with all patients in the present study reporting no limitations in daily life.

Tarantino et al. (2006) surveyed 51 women who were at least 10 years post breast reconstruction by LD flap and prosthesis. The survey included some questions concerning shoulder function for morbidity, force and subjective disability. Results revealed that over one third (35%) of women complained of a moderate to severe loss of shoulder force and limitations in shoulder function. Impairment in daily activity was graded moderate to severe by 22% of patients. Regarding shoulder function, they found a limitation of abduction and elevation in two cases and in 22 cases a raised shoulder on the operated side at rest. These findings suggest that in contrast to that reported by Bonomi et al. (2012), women can sustain impaired shoulder strength and reduced function in the long term, with some women reporting moderate to severe impairment in daily activities more than 10 years following surgery. A more recent survey conducted by Losken et al. (2010) retrospectively evaluated patients following bilateral LD breast reconstruction with a follow up of two years. They assessed shoulder function using a patient satisfaction survey (n=37) evaluating outcomes such as aesthetic results, general satisfaction, morbidities and functional assessment. They found that most patients reported no impairment in ADL, however, 27% of patients
did report some impairment; most stating that their arm felt slightly weaker or stiff. When specifically queried about shoulder function one fifth of patients reported a slight impairment with 2% reporting shoulder function to be significantly impaired. With regard to shoulder ROM similar results were presented with one fifth of patients reporting a slight decrease in ROM, while 2% found their ROM to be significantly decreased. These findings suggest that medium to long term functional impairment is a potential consequence of this surgery. However, similar to Tarantino et al. (2006) assessing functional recovery was not the authors’ primary aim and with no validated questionnaire used it is therefore difficult to compare results between studies.

A survey by Ditsch et al. (2013) retrospectively investigated women’s (n=89) experiences of four different allogenic or autologous methods of breast reconstruction following mastectomy. The study addressed issues such as physical complaints, functional impairments and patient satisfaction following surgery, with an average follow up of approximately five years. Nearly half of the women who received autologous tissue reconstruction were restricted in movement, with authors highlighting a significantly stronger movement restriction in patients who underwent LD reconstruction in comparison to the TRAM group (p=0.009). Kaariainen et al. (2014) evaluated the influence of LD flap innervation on the functional and aesthetic outcome of delayed LD breast reconstruction through questionnaire survey. Twenty-eight patients were randomised into two groups: denervated group (n=14) and innervated group (n=14). Patients were clinically evaluated and also completed a questionnaire considering the functional and aesthetic outcome of surgery one year postoperatively. The findings from this study revealed that shoulder joint mobility was not found to be significantly different in either the innervated nor denervated groups and that there were no limitations in ADL reported. These results depict the subjective evaluation of the functional outcome of two different methods of LD reconstruction one year postoperatively. The findings suggest that neither the innervated nor denervated LD flap affect the functional ability of the patients concerned. However, no standardised methods of assessment were used and no pre-surgery assessment was carried out.

Hamdi et al. (2008) recruited 22 patients in order to evaluate shoulder function following a partial breast reconstruction using a pedicled thoracodorsal artery perforator flap. This study challenged the standard technique for performing LD harvest and proposed the use of the thoracodorsal artery perforator flap as an alternative for sparing the LD muscle. Muscle strength and shoulder mobility were measured postoperatively using MicroFet2 and a goniometer, with an average follow up of 19 months; results were analysed comparing the operated and non-operated side. When comparing the operated to the non-operated sides, LD strength appeared to be maintained following surgery, with shoulder mobility similar in all movements (p=0.794). However, significant decreases
were found in active elevation (p=0.041), passive elevation (p=0.017) and passive abduction (p=0.018) of the operated shoulder when compared with the non-operated side. Follow-up ranged from six to 45 months postoperatively suggesting that surgery had little impact on both short and long term recovery; however, the authors did not distinguish between results for specific recovery time points therefore making it difficult to apply these findings generally based on the small sample size. Moreover, a similar study conducted by Kim et al. (2013) compared morbidity of the donor site following pedicled muscle-sparing LD flap (n=36) versus an extended LD flap (n=37) in unilateral breast reconstruction. Donor site complications were evaluated in patients following surgery, including limitation of shoulder movement. To measure shoulder limitation, a physical assessment was conducted four weeks and then six months post-surgery comparing the operated to the non-operated side, and active ROM was assessed in the shoulder as well as overhead-reach with differences compared between shoulders. The results showed that over 75% of patients who underwent extended LD flap demonstrated significantly limited shoulder movement four weeks post-surgery compared to 25% of those who underwent muscle sparing LD transfer. Limitations in shoulder ROM were noted in both groups, however, the muscle sparing method was associated with significantly less morbidity (p=0.0001).

An observational study conducted by Rifaat et al. (2008) prospectively evaluated the efficacy of the extended LD flap as an option in autologous breast reconstruction (n=14). Preoperative assessment included physical examination with the follow-up period ranging from six to 18 months. Authors stated that most patients had a temporary limitation of shoulder movements postoperatively, however, they did not specify exactly how many patients endured these limitations. The authors commented that this surgery had an impact on shoulder function based on findings highlighted within their literature review, suggesting that the functional deficit is usually low, although, they did note that LD breast reconstruction should be avoided in those who participate in sporting events such as swimming. However, no description is given for the method of physical examination carried out upon which their conclusions are based. In addition, the evaluations are based upon a relatively small sample size and findings from studies conducted between 1983 and 2006; therefore these results may be somewhat dated and perhaps do not reflect the current body of literature around this topic.

A more recent study conducted by Eyjolfsdottir et al. (2016) prospectively analysed functional outcomes following extended LD flap breast reconstruction. Bilateral shoulder ROM was assessed in patients (n=15) preoperatively at one, six and 12 months postoperatively, using goniometry. In addition, muscular strength was measured using pulleys and weights. The ROM assessments revealed that shoulder flexion and abduction had
significantly reduced at one month postoperatively (p=0.01 and p=0.03, respectively), however, ROM returned to the preoperative values 12 months following surgery. Regarding muscular strength, the results demonstrated that by 12 months, shoulder extension, adduction and internal rotation were significantly decreased when comparing the operated to the non-operated side. These findings indicate that although ROM may be regained following surgery, reductions in strength may persist long-term. The authors commented that the reason they chose to compare sides, as opposed to the preoperative and postoperative values, was based on the assumption that patients may have been training arm muscles during that period. As no direct comparison can be made, it is difficult to interpret the extent of dysfunction among this group. Furthermore, a long-term prospective assessment of shoulder function following LD breast reconstruction was carried out by Sowa et al. (2016). ROM and strength was measured in patients (n=18) before surgery, and at three, six, 12 and 36 months postoperatively. The ROM measurements showed statistically significant decreases in flexion and abduction at three months (7.1 and 9.2% respectively) and three years (4.7 and 5.7% respectively) following surgery. Regarding muscular strength, significant decreases were evident in adduction and medial rotation at both three months postoperative and at the three year follow-up assessment. The findings from this study suggest that there is a significant loss of shoulder strength and ROM when compared to the preoperative values, with the greatest recovery evident during the six month period following surgery.

Forthomme et al. (2010) prospectively assessed dynamic shoulder function in patients (n=20) following LD breast reconstruction. Bilateral shoulder isokinetic assessment of the shoulders (for the internal and external rotators and the abductor and adductor muscles) was performed before surgery and three and six months postoperatively. The isokinetic assessment showed muscle weakness both at three and six months after surgery, highlighting weakness in the adductors and internal rotators six months post-surgery. As perhaps anticipated, shoulder function significantly decreased after surgery on the operated shoulder, demonstrating the functional deficits that can occur immediately following LD muscle transfer. An important finding was the significant deficit found in the bilateral comparison on the operated shoulder for the adductors and internal rotators six months following LD transfer. None of the patients reported any occupational difficulty due to shoulder instability; however, women frequently described muscle fatigue when the operated side was involved in prolonged overhead daily activities and sporting activities such as swimming or climbing, with limitations more frequently reported in women who had undergone surgery on their dominant side. The authors concluded that muscle weakness following LD muscle transfer should be expected and demonstrate the potential functional sequelae associated with this surgery.
The first of two observational studies conducted by de Oliviera et al. (2010), compared the recovery of shoulder ROM, in women who had mastectomy alone (n=46) and in women who had undergone immediate LD breast reconstruction following mastectomy (n=41). Shoulder ROM was assessed using goniometry, prior to surgery and on a weekly basis during the first four weeks postoperatively. The authors found that at the end of the follow-up period, women in both groups had an average reduction of 30° in their shoulder ROM compared with baseline. They suggested that any reductions in shoulder ROM were possibly due to mastectomy alone and that LD breast reconstruction had no additional detrimental effects on shoulder function; however, as no long term follow up was carried out these findings can only be associated with the expected short term recovery of shoulder ROM in the immediate postoperative period. In the follow-up study by de Oliveira et al. (2013), they re-examined recovery of shoulder ROM during the first year following immediate LD breast reconstruction. Shoulder ROM was assessed in patients (n=47) before, after one month and at three, six and twelve months following LD breast reconstruction. They found a 30% decrease in shoulder ROM one month after surgery, with progressive recovery over time. This study concluded that the LD flap was not associated with restriction of flexion or abduction and in turn did not negatively impact shoulder function following surgery. However, findings from the study showed that mean abduction and flexion capacities did not return to baseline, and were on average 5-10% lower, even after one year following surgery, and these results highlight the potential reduction in shoulder ROM that can remain one year post-surgery as demonstrated by other authors (Glassey et al. 2008; Yang et al. 2015).

A large scale study conducted by Winters et al. (2013) prospectively evaluated patient-reported outcome measures in implant-assisted (n=82) and autologous (n=100) LD flap breast reconstruction. They assessed health-related quality of life (HRQL) using validated self-report questionnaires, some of which focussed on the functional impact of breast cancer and its treatment. Questionnaires were completed before surgery and at three, six and 12 months postoperatively with the authors comparing short (0-3 months) and long-term (4-12 months) complications in women between groups. Long-term complications included restriction in arm and shoulder movement, which was evident in 15% of implant-assisted and 11% of autologous reconstructions, with a further 15% and 29% of patients reporting back symptoms including stiffness, tightness and discomfort respectively. Results demonstrated that many of the HRQL outcomes diminished, (i.e. their health status had deteriorated) from baseline to three months however improved by 12 months postoperatively. In 2016, Winters et al. conducted an extended follow-up, evaluating the impact of implant-assisted (n=93) and autologous (n=113) LD flaps on a wide range of domains, before surgery and two and three years after breast reconstruction. The results from this study demonstrated that regardless of reconstruction method, notable deteriorations in a number of outcomes, including physical function,
persisted at two and three years following surgery. These findings suggest that decreased functional mobility can persist up to three years following surgery, irrespective of the method of LD breast reconstruction.

**Discussion**

The aim of this review was to comprehensively assess the musculoskeletal impact of LD breast reconstruction and evaluate the functional outcome of surgery. The results have demonstrated that, despite the methodological variations in included papers there is sufficient evidence to suggest that women who have LD reconstruction as a consequence of breast cancer will experience some degree of weakness and reduced mobility following LD muscle transfer. The literature demonstrates considerable morbidity in the immediate postoperative period with functional recovery over time varying between studies. As a result, there appears to be no consensus in the literature regarding the extent and impact of breast reconstruction using LD flap on musculoskeletal function. The LD muscle is a fundamental component involved in shoulder function, essential in internal rotation, extension and shoulder adduction (Forthomme et al. 2010; Giordano et al. 2011; Bhatt et al. 2013; Sowa et al. 2016). There have been many studies examining the application of the LD flap in various forms of reconstruction; however, relatively few studies have been conducted with regard to the functional impairment associated with LD muscle transfer in breast reconstruction.

With regard to flap types, the majority of research indicates that sparing the LD muscle can result in less functional implications than other types of LD flaps used. Results from a comparative study revealed that the LD muscle sparing flap was shown to be associated with significantly less morbidity (p=0.0001) than the extended LD flap (Kim et al. 2013). This study supports other research conducted suggesting that sparing the LD muscle can result in less functional limitations than other methods of autologous LD breast reconstruction (Hamdi et al. 2008; Saint-Cyr et al. 2009; Brackley et al. 2010). On the other hand, a comparative analysis of three different types of LD flaps, including: standard LD flap with implant, muscle sparing LD flap with implant and autologous LD flap revealed that sacrificing the LD muscle had minimal functional impact on shoulder function with no detrimental effects evident between groups (Bonomi et al. 2010).

Approaches to the assessment of shoulder morbidity following LD muscle transfer varies across the literature. Studies have implemented a wide range of assessment techniques including objective measurements of shoulder function, and subjective evaluations by patients and their clinicians. Objective measurements have portrayed varying results, however, a commonality between studies is that most report significant deficits in the immediate
postoperative period (Forthomme et al. 2010; Kim et al. 2013; Yang et al. 2015; Eyjolfsdottir et al. 2016), with results demonstrating a gradual recovery over time (Glassey et al. 2008; de Oliviera et al. 2013). A number of subjective evaluations suggest low morbidity with minimal functional impact (Losken et al. 2010; Kaarianinen et al. 2014; Garusi et al. 2016), however, in a retrospective survey, findings reported that women can sustain impaired shoulder strength and reduced function long term, with some women reporting moderate to severe impairment in daily activity more than ten years following surgery (Tarantino et al. 2006). In addition, results collected from DASH demonstrate varying results, some authors have reported substantial morbidity following surgery, however, the length of disability sustained is inconsistent (Koh and Morrison 2009; Button et al. 2010; Bonomi et al. 2013; Van Huizum et al. 2016), highlighting the lack of consensus within the literature.

The Association of Breast Surgery (ABS) and the British Association of Plastic and Reconstructive and Aesthetic Surgeons (BAPRAS) released oncoplastic breast reconstruction guidelines for best practice in 2012. These guidelines give detailed information regarding the postoperative recovery phase and state that information should be given to patients regarding exercise and physiotherapy, anticipated recovery timelines and follow-up procedures. These recommendations state that any movement that causes the LD muscle to contract, or stretches the LD or Pectoralis Major should be avoided until the wounds have healed. Within the first two weeks post LD flap surgery; shoulder shrugs and shoulder rolls are advised and normal use of the arm is encouraged for light activities up to shoulder height. Following two weeks postoperative progressive ROM exercises are advised with gradual return to normal use of the arm above shoulder height. Return to all normal activities by six to eight weeks postoperatively is encouraged, with heavy household tasks avoided until 12 weeks postoperatively. These timescales are identified as broad recommendations with the authors highlighting that timescales will vary on an individual case basis, and that all exercise prescription should be tailored to the individual patient.

Identifying the musculoskeletal consequences of breast reconstructive surgery using LD and determining effective rehabilitation could in turn promote increased QoL. Research suggests that rehabilitation is essential in order to delay the onset of musculoskeletal damage following breast surgery, with exercise interventions being beneficial and causing no serious harm (Chan et al. 2010; Kilbreath, 2011; McNeely et al. 2012; Loh and Musa, 2015). A review carried out by McNeely et al. (2012) highlighted the importance of exercise interventions in order to significantly improve shoulder ROM following breast surgery in women, and a review conducted by Chan et al. (2010) found the early introduction of exercise to be crucial in avoiding deterioration in shoulder ROM. Furthermore, Loh and Musa (2015) assessed methods to improve rehabilitation of patients following breast cancer
surgery. The authors found that including exercise rehabilitation showed significant improvement in shoulder movement, irrespective of type or period of implementation, however, early exercise was found to be more effective than delayed exercise. Therefore, with the evidence suggesting that LD breast reconstruction does lead to reductions in function, tailored exercise rehabilitation can be recommended in order to promote return to normal activities in a safe and progressive manner. In addition, improving physical functioning can have benefits beyond improving upper limb mobility and extend to other aspects of health related QoL, for example, improving cardiovascular health (Pinto et al. 2003), facilitating return to work (Hoving et al. 2009), and return to functional roles at home (Spence et al. 2010).

This diversity of findings between studies could be a result of a number of factors including the variety of techniques used to measure shoulder function with a range of equipment. Also, there appears to be no regular or standardised follow-up period making it difficult to predict recovery timelines on a larger scale. In addition, many studies were of a retrospective nature and limited due to small sample size. A number of authors reported a significant dropout rate during follow-up, which may have implications on the results in some studies. Furthermore, dominance is an important variable, however, it was not always considered when comparing the operated and non-operated side. In view of that, the literature would support the theory that there is a certain degree of synergistic compensation by the remaining shoulder muscles over time (Glassey et al. 2008; Forthomme et al. 2010). Nonetheless, conflict exists within the literature regarding the impact of surgery on shoulder function and the potential extent of associated donor-site morbidity. The majority of work exploring the musculoskeletal consequences of breast reconstruction tends to be limited due to small sample size, of a retrospective nature and often gives conflicting results. Consequently, LD flaps are perhaps not as benign as previously understood and disabilities that result as a consequence of surgery may in reality be more common than previously reported. The extent and impact of the musculoskeletal consequences of breast reconstruction have yet to be fully established, therefore, further investigation is required in order to determine underlying factors that could contribute to reductions in function and ADL.
References:


