Novel Garment Heralds the Emergence of a New "Stiffer Circular Knit" Compression Category

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COMPRESSION PRESSURE

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S.T.R.I.D.E.™ Professional Guide to Compression Garment Selection for the Lower Extremity

An algorithm incorporating both textile characteristic and oedema presentation to optimize medical compression garment selection.

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“Lymphedema” is a continuum of chronic edemas

- Although lymphedema is commonly encountered, it is erroneously believed to be a rare disorder
- LIMPRINT (**L**ymphedema **IM**pact and **PR**evalence **INT**ernational) 2019 Study defines a broader definition of “lymphedema”: ***Chronic edema which has been present for more than three months*** [(1)].
  - LIMPRINT Australia findings (224 participants)[(2)]:
    - Lymphedema in Residential Care Facilities: 54%
    - Lymphedema in community aged-care services: 24%
    - Lymphedema in hospital setting: 28%
    - Lymphedema in wound treatment center: 100%
  - LIMPRINT Canada findings (68 participants)[(3)]:
    - Lymphedema in OP Wound Management Clinic: 24%

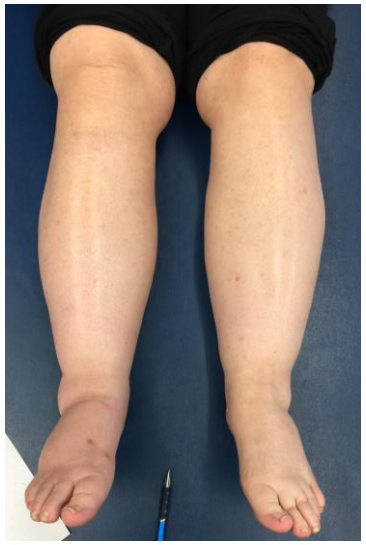
- An estimated **10 million** people are affected by lymphedema in the U.S with many more underdiagnosed [(4)]

That’s more than people with MS, ALS, Parkinson Disease and AIDS COMBINED

Compression is a recognized treatment/management for lymphatic disease...

Compression is also a continuum!













If dosage was all that mattered, all 30-40mmHg garments would have the same effectiveness….but they do not….why?

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Beyond Dosage…Stiffness Matters

- Stiffness provides insight into the performance during posture changes and movement and impacts edema prevention and hemodynamics [12-15]

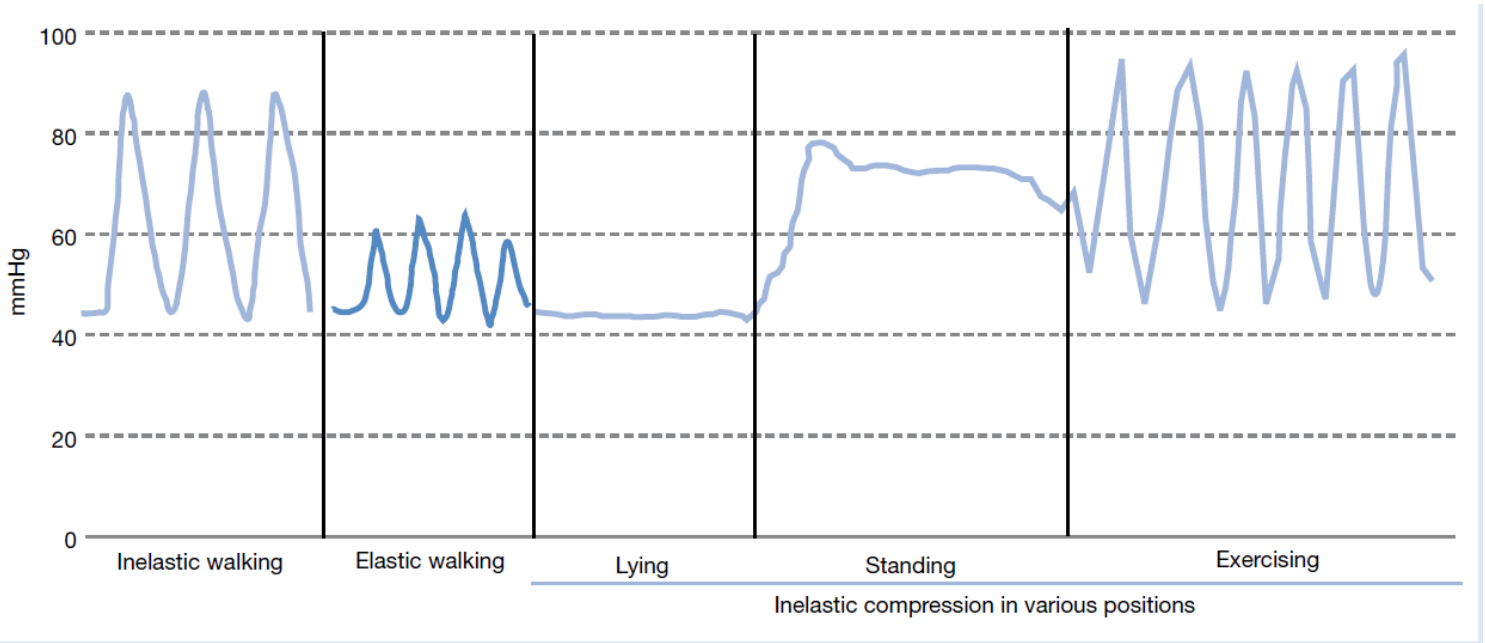


Fig 6. Graphic tracing of interface pressure measurements under inelastic and elastic compression with movement.

- ✓ Dosage describes the inward pressure that a garment exerts on the body as a result of its elastic recoil [16]
- ✓ While stiffness describes the resistance of the garment to the expansion [16]
  - such as when an area of body swells
  - tissue expands due to muscle contraction

Beyond the Dosage… Stiffness Matters

- Multiple researches have found variations of stiffness of MCS independent of dosage and type of knitting

  - There is a statistically significant difference in capillary filtration rate, and consequently in the development of edema,….. between elastic compression stockings with the same compression (mmHg), but a low slope profile (lower stiffness) and a high slope profile (higher stiffness). (17)

  - In patients with a strong tendency to develop edema it may be advisable to prescribe stockings with a high slope profile (stiffness). (17)

  - Although compression devices may apply similar resting pressures, materials with no stretch or short-stretch bandages produce higher peak pressures when standing or walking compared with the effects obtained with long-stretch devices (18)

18 Different Class II Garments – static stiffness ranged from 1.7 to 10.32!

Table 1 The static and the dynamic stiffness index of 18 different brands of MECS.

		Brands of MECS	Static stiffness [mmHg/cm]	Mean DSI* ± SD [mmHg/cm]
Class II 23 to 32 mmHg	Round-knitted		2.63	18.45 ± 0.40
			2.87	16.15 ± 0.92
			3.52	17.89 ± 0.15
			1.70	16.06 ± 0.27
	Flat-knitted		2.88	18.62 ± 1.04
			3.95	26.26 ± 1.06
			2.95	23.34 ± 1.09
			10.32	32.21 ± 1.19
			2.91	23.62 ± 0.89
			3.78	19.45 ± 0.40
			3.39	22.79 ± 0.79

19. van deWegen-Franken, C. P. M. (2009). Medical elastic compression stockings (Doctoral dissertation, Erasmus MC: University Medical Center Rotterdam).

Effective compression selection is a balancing act

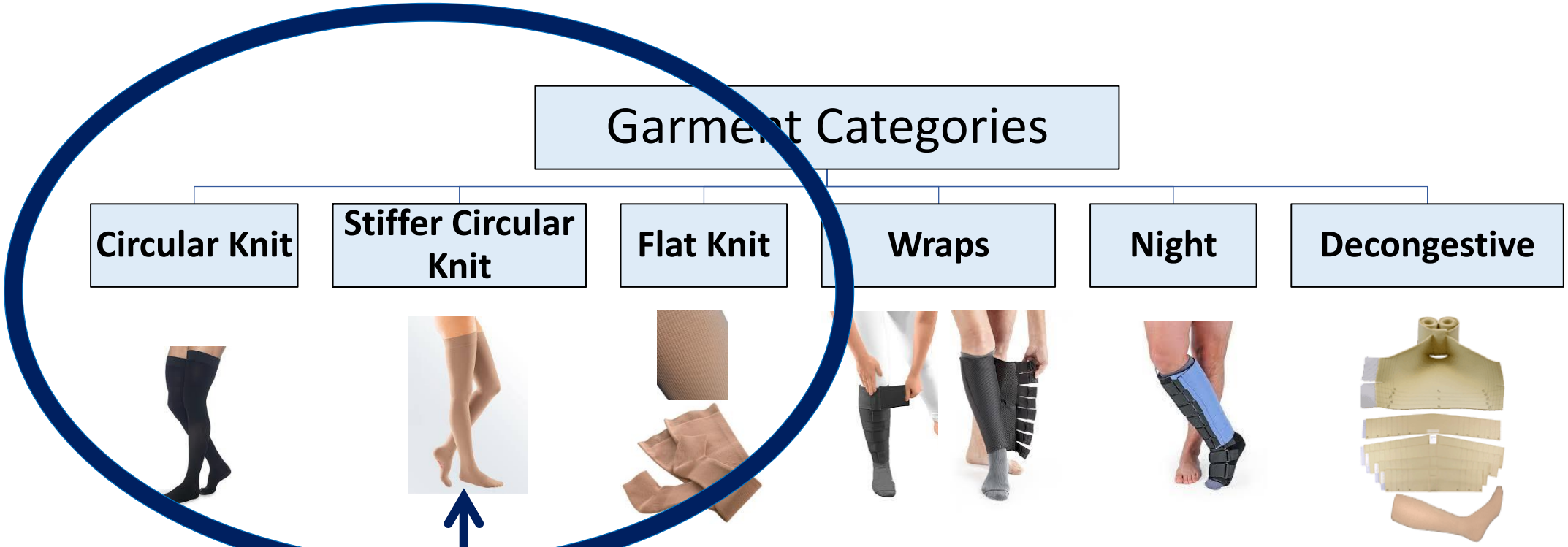
Textile Specific	Patient Specific
Dosage	Location of swelling
Stiffness	Quality of Swelling
Texture	Mobility/Functional Impairments
Garment Style	Socio-economical (cost and support)

What is S.T.R.I.D.E.™?

- Extensive literature review summarizing the science of compression textiles
- Define garment categories

- Offers a practical, step by step guide to compression selection
  - ✓ matching compression textile to patient presentation

Why are there 3 knitted garment categories?



"Stiffer Circular Knit" achieved with denser knitting pattern, high modulus inlay yarns (resist fatigue), more even distribution of dosage and stiffness

New Category "Stiffer Circular Knit" vs Traditional Circular Knit

Garment Category, Dosage & Size:	Stiffer Circular Knit (SCK), 30-40mmHg, Medium		
Profile:	Average mmHg	% Gradient (% mmHg compared to ankle)	Average Stiffness
Foot	25.95	71%	2.74
Ankle	36.46	100%	3.18
Calf	24.71	68%	1
Thigh	15.5	43%	0.46
Ankle Circumference	21.5 - 25.5cm		

Garment Category, Dosage & Size:	Circular Knit (CK) (Sheer), 30-40mmHg, Medium		
Profile:	Average mmHg	% Gradient (% mmHg compared to ankle)	Average Stiffness
Foot	16.28	47%	1.14
Ankle	34.51	100%	1.3
Calf	17.51	51%	0.44
Thigh	8.85	26%	0.15
Ankle Circumference	21.5 - 25.5cm		

Note: All garments are the same dosage and size, and all garments were manufactured by the same company and tested using a Zwick machine. A commercial software program was used to produce a hysteresis curve and calculate stiffness. *(Data provided courtesy of Sigvaris Group, Inc., USA)*

New Category "Stiffer Circular Knit" vs Traditional Flat Knit*

Garment Category, Dosage & Size:	Stiffer Circular Knit (SCK), 30-40mmHg, Medium		
Profile:	Average mmHg	% Gradient (% mmHg compared to ankle)	Average Stiffness
Foot	25.95	71%	2.74
Ankle	36.46	100%	3.18
Calf	24.71	68%	1
Thigh	15.5	43%	0.46
Ankle Circumference	21.5 - 25.5cm		

Garment Category, Dosage & Size:	Flat Knit (FK), 30-40mmHg, Custom - "Medium" (sized for same leg as used for CK & SCK)		
Profile:	Average mmHg	% Gradient (% mmHg compared to ankle)	Average Stiffness
Foot	Not Tested		
Ankle	37.67	100%	6.3
Calf	14.08	37%	2.34
Thigh	5.39	14%	0.71
Ankle Circumference:	24cm		

Note: All garments are the same dosage and size, and all garments were manufactured by the different companies and tested using a Zwick machine. A commercial software program was used to produce a hysteresis curve and calculate stiffness. *(Data provided courtesy of Sigvaris Group, Inc., USA)*

Taking Compression Garment Selection in S.T.R.I.D.E.™

Selection of compression garment necessitates matching compression garment to the patient presentation and abilities.

- **S**hape – What is shape of leg? Where is the swelling?
- **T**exture – What is the texture of the tissue? Textile Texture?
- **R**efill – How quickly does the swelling rebound? Swelling at night?
- **I**ssues – Precautions? Functional limits? Caregiver support? Costs?
- **D**osage – Dosage based on underlying medical etiology
- **E**tiology – diagnoses and co-morbidities contributing to the edema

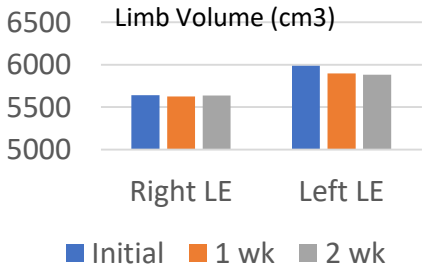
Results

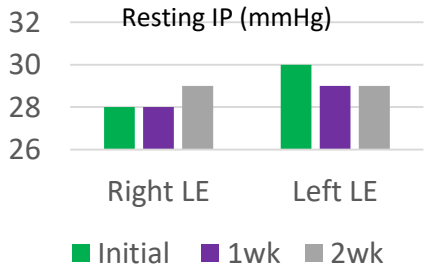
- **S**hape
  - Limb - normal
  - Distribution – right below knee, left to thigh
  - Garment – RTW OR custom
- **T**exture
  - Tissue – right leg soft putty
    - Left distal 2/3 leg woody fibrotic
  - Textile – stiffer textile to contain and bridge

- **R**efill – Rapid refill, does not go down at night
- **I**ssues – arm/leg weakness, obesity, cost
- **D**osage – 20-30mmHg, 30-40mmHg circ knit firm stiffness, layering garment, class II flat knit
- **E**tiology – Venous, lymphedema

Texture					Refill		Issues	Recommended Garment Categories/Subcategories & Dosage (Note: Refer to ABI Guidance)						
TISSUE TEXTURE	WATERY	FATTY	FIBROTIC	RECOMMENDED TEXTILES	RECOMMENDED DAY OR NIGHT COMPRESSION	SLOW REFILL or RAPID REFILL	ABI GUIDANCE (see ABI Guidance doc) - Applies to all Edema Etiologies	CIRCULAR KNIT DOSAGE & SUBCATEGORY: LIGHT (L), REGULAR (R), FIRM (F)	STIFFER CIRCULAR KNIT DOSAGE & SUBCATEGORY: LIGHT (L), REGULAR (R), FIRM (F)	FLAT KNIT DOSAGE & SUBCATEGORY: LIGHT (L), REGULAR (R), FIRM (F)	ADJUSTABLE WRAPS DOSAGE & SUBCATEGORY: LIGHT (L), REGULAR (R), FIRM (F)	NIGHT DOSAGE & SUBCATEGORY: (L), REGULAR (R), FIRM (F)			
N/A	N/A	N/A	N/A			N/A	☐ >1.40: Falsely elevated	15-20mmHg (L)						
N/A	N/A	N/A	N/A			N/A		15-20mmHg (20-30mmHg post-procedure) (L)						
N/A	N/A	N/A	N/A			N/A		20-30mmHg (L)						
	YES	YES, if obese	If present, go to Stage 2 or 3 Lymphedema			SR	☐ 1 to 1.40: Normal - safe to use all levels of compression (15-20, 20-30,	20-30mmHg or 30-40mmHg consider layering (R or F)	20-30mmHg or 30-40mmHg, consider layering (L or R)	Class I (18-21mmHg) - Class II (23-32mmHg) (or R)	20-30 or 30-40 Resting mmHg (L or R)		40 Resting mmHg (L or R)	(phlebolymphedema)	
	YES	YES, if obe	If present, go to Stage 2 or 3 Lymphedema			SR		30-40mmHg or higher, consider layering (R or F)	0-30mmHg, 30-40mmHg or higher, consider layering (R)	Class I (18-21mmHg) - Class II (23-32mmHg) (R)	20-30 or 30-40 Resting mmHg (R)		RTW Wraps; 20-30 or 30-40 Resting mmHg (R)	CVI - CEAP: C4 (phlebolymphedema)	Pigmentation, eczema, lipodermatosclero atrophie blanche
	YES	YES, if obese	If present, go to Stage 2 or 3 Lymphedema			SR	☐ 0.91 to 0.99: Borderline PAD - safe to use all levels compression (15-20, 20-30, 30-40, 40-50mmHg)	30-40mmHg or higher, consider layering (R or F)	0-30mmHg, 30-40mmHg or higher, consider layering (R)	Class I (18-21mmHg) - Class II (23-32mmHg) (R)	20-30 or 30-40 Resting mmHg (R)		RTW Wraps; 20-30 or 30-40 Resting mmHg (R)	CVI - CEAP: C5 (phlebolymphedema)	Healed venous ulcer
	YES	YES, if obese	If present, go to Stage 2 or 3 Lymphedema			SR		30-40mmHg or higher, consider layering (R or F)	0-30mmHg, 30-40mmHg or higher, consider layering (R)	Class I (18-21mmHg) - Class II (23-32mmHg) (R)	20-30 or 30-40 Resting mmHg (R)		RTW Wraps; 20-30 or 30-40 Resting mmHg (R)	CVI - CEAP: C6 (phlebolymphedema)	Active venous ulcer
	YES	YES, if obese	If present, go to Stage 2 or 3 Lymphedema			SR		20-30mmHg (R or F)	20-30mmHg (L or R)	Class I (18-21mmHg) - or R)	0-30 Resting mmHg (L or R)		RTW Wraps; 20-30 Resting mmHg (L or R)	Dependent Edema	Resulting from dependency of body part and lack of movement
	YES	YES, if obese	If present, go to Stage 2 or 3 Lymphedema			SR or RR	☐ 0.8 to 0.90: Mild PAD - apply compression with caution (15-20, 20-30, 30-40mmHg)	15-20mmHg or 20 to 30mmHg (R or F)	20-30mmHg (L or R)	Class I (18-21mmHg) - or R)	0-30 Resting mmHg (L or R)		RTW Wraps; 20-30mmHg (L or R)	Congestive Heart Failure	Heart is unable to pump blood effectively, resulting in fluid retention in the body
	YES	YES, if obese	If present, go to Stage 2 or 3 Lymphedema			SR or RR		20-30, 30-40mmHg or higher consider layering (R or F)	20-30, 30-40mmHg or higher, consider layering (R or F)	Class I (18-21mmHg) - Class II (23-32mmHg) (R or F)	20-30 or 30-40 Resting mmHg (R or F)		RTW wraps; 20-30mmHg (R or F)	Chronic Kidney Disease	Insufficient or failure of kidney function resulting in fluid retention in the body
	N/A	N/A	N/A			N/A	☐ 0.51 to 0.79: Moderate PAD. Use modified compression with caution. Absolute systolic ankle pressure should be >60mmHg (Lurie et al, 2019). Short stretch or inelastic garments safer than elastic compression for lower ABI, or use reduced compression pressure (15-20, 20-30mmHg) for elastic garments.	15-20mmHg (L)						Stage 0 Lymphedema	A latent or sub-clinical condition where swelling is not yet evident despite impaired lymph transport, subtle alterations in tissue fluid/composition, and changes in subjective symptoms. It may exist months or years before overt edema occurs.
	N/A	YES	YES, if obese	NO		SR or RR		20-30mmHg (R or F)	20-30mmHg (L or R)	Class I (18-21mmHg) Class II (23-32mmHg) (or R)	0-30 Resting mmHg (L or R)	20-30 Resting mmHg (L or R)	Customizable Wraps; 20-30 Resting mmHg (L or R)	Stage 1 Lymphedema	Early accumulation of fluid relatively high in protein content (e.g., in comparison with venous edema) which subsides with limb elevation. Pitting may occur. An increase in various types of proliferating cells may also be seen.
	NO	YES, abnormal fat deposition	YES			SR or RR		30-40mmHg or higher, consider layering (F)	20-30 or 30-40mmHg, consider layering (L or R)	Class II (23-32mmHg) Class III (34-46mmHg) (L or R)	20-30 or 30-40 Resting mmHg (L or R)	20-30 or 30-40 Resting mmHg (L or R)	Customizable Wraps; 20-30 or 30-40 Resting mmHg (L or R)	Stage 2 Lymphedema	Limb elevation alone rarely reduces the tissue swelling and pitting is manifest.
	NO	YES, abnormal fat deposition				SR or RR			20-30, 30-40mmHg or higher, consider layering (R or F)	Class II (23-32mmHg) Class III (34-46mmHg) (R or F)	0-40 Resting mmHg (R or F)	30-40 Resting mmHg (R or F)	Customizable Wraps; 30-40 Resting mmHg (R or F)	Late Stage 2 Lymphedema	Limb may not pit as excess subcutaneous f fibrosis develop.

GARMENT CHOICE: Flat knit with donning aide

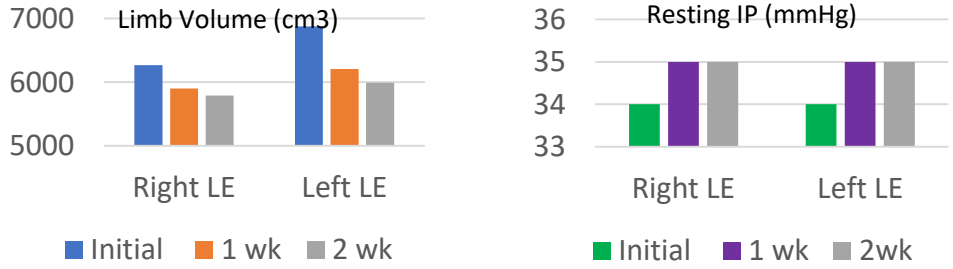


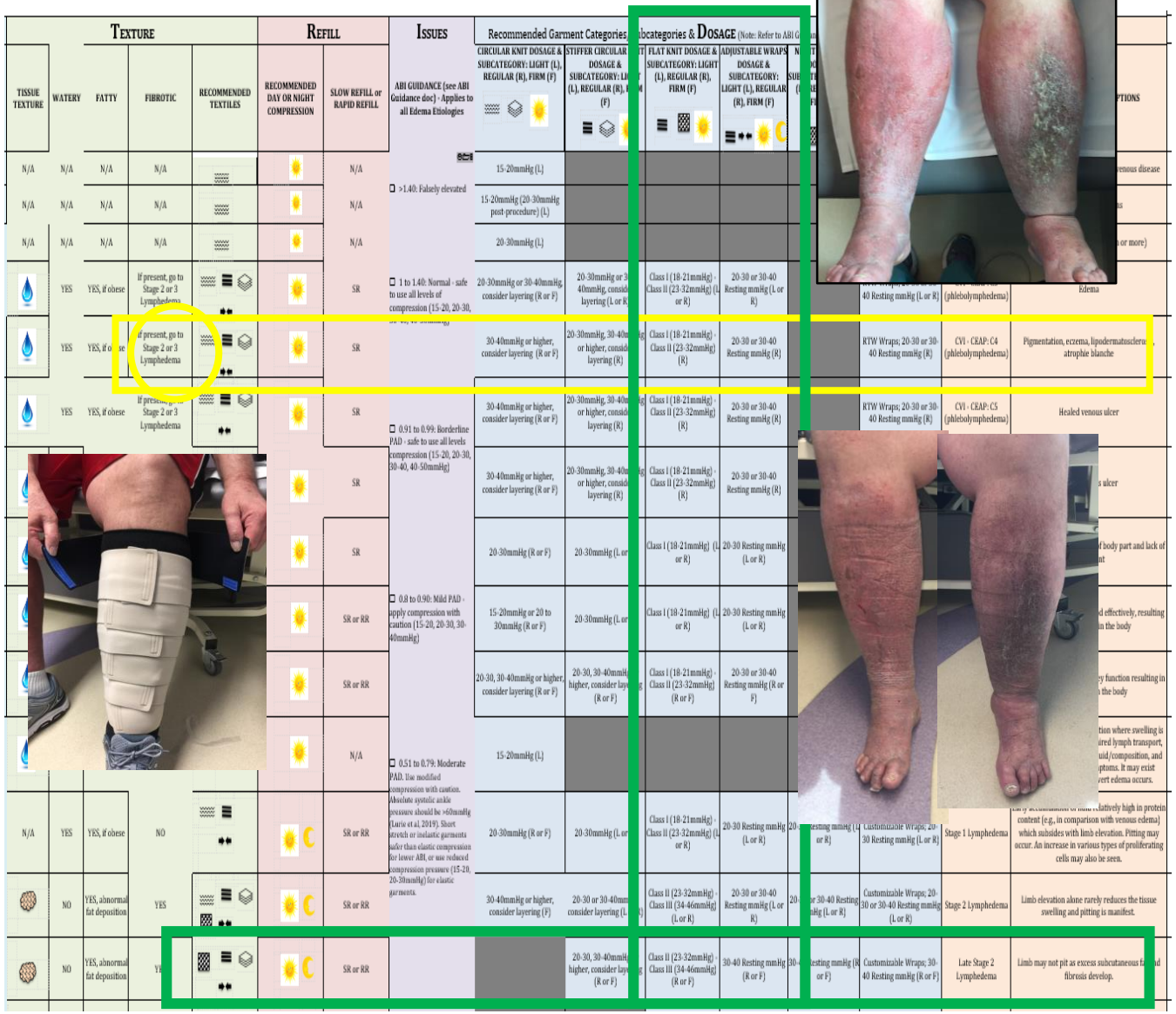


Results

- **S**hape
  - Limb – cylinder/column
  - Distribution – below knee, mild foot
  - Garment – RTW OR custom
- **T**exture
  - Tissue – firm putty/woody
  - Textile – stiffer textile to contain, textured, adjustable
- **R**efill – Rapid refill during day and night
- **I**ssues – peripheral neuropathy, CHF, end-stage lymphoma, wound drainage, pt did not like anything over his toes, finance
- **D**osage – 20-30mmHg, 30-40mmHg circ knit firm stiffness, layering garment, class II flat knit
- **E**tiology – CVI=C6, PTS, lymphoma, CHF, h/o polio with altered muscle pump

GARMENT CHOICE: Velcro Adjustable Wrap





Taking Compression Garment Selection in S.T.R.I.D.E.™

- Compression dosage (mmHg) is only one of the variables that impact edema and hemodynamic efficacy of a compression garment
  - ✓Comprehensive assessment of etiology
  - ✓Presentation of edema
  - ✓Abilities of the patient
  - ✓Dynamic performance of the compression textile
- Knowledge of compression science and individual textile characteristics is key

- S.T.R.I.D.E.™ compression garment selection algorithm is a practical, evidence based clinical tool to assist healthcare providers with effective compression garment prescription.
  - Bjork R, Ehmann S. S.T.R.I.D.E.™ Professional guide to compression garment selection for the lower extremity. J Wound Care. 2019;28(6 suppl):1-44.

Thank You!!

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Be part of the compression revolution!!

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